Federal Greenhouse Gas Accounting and Reporting Guidance

Technical Support Document for Recommendations to the Council on Environmental Quality on Section 9 of Executive Order 13514

DRAFT V2 DOCUMENT – DO NOT QUOTE OR CITE

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Contents

Figures

Tables

Acronyms

BOD	biological oxygen demand
CAS	Chemical Abstract Service
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHP	combined heat and power
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DLA	Defense Logistics Agency
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
EERE	Energy Efficiency and Renewable Energy
EISA	Energy Independence and Security Act
EO	executive order

EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCRA	Emergency Planning and Community Right-To-Know Act
FAQ	frequently asked questions
FAST	Federal Automotive Statistical Tool
FEMP	Federal Energy Management Program
FR	Federal Registry
FY	fiscal year
GE	goal-excluded
GHG	greenhouse gas
GOCO	government owned / contractor operated
GS	goal-subject
GSA	General Services Administration
GWP	global warming potential
HFC	hydrofluorocarbon group of gases
HVAC	heating, ventilation and air conditioning
IAPWS	International Association for the Properties of Water and Steam
ICFPA	International Council of Forest and Paper Association
IPCC	Intergovernmental Panel on Climate Change
LANDGEM	Landfill Gas Emission Model
LEV	low emission vehicle
LFG	landfill gas
LMI	Logistics Management Institute
MRR	Mandatory Reporting Rule
MSDS	Material Safety Data Sheet
MSW	municipal solid waste
MT	metric tons
NMOC	non-methane organic compounds
OSMIS	Operating and Support Management Information System
NECPA	National Energy Conservation Policy Act
NERC	North American Electric Reliability Council
NF_3	nitrogen trifluoride

N$_2$O	nitrous oxide
ODS	Ozone Depleting Substance
OFEE	Office of the Federal Environmental Executive
OMB	Office of Management and Budget
PFC	perfluorocarbon group of gases
PNR	Passenger Name Record
POC	point-of-contact
PSS	*Public Sector Standard*
REC	renewable energy certificate
RGGI	Regional Greenhouse Gas Initiative
SF$_6$	sulfur hexafluoride
TCR-LGOP	The Climate Registry's Local Government Operations Protocol
T&D	transmission and distribution
TRI	Toxic Release Inventory
TSD	Technical Support Document
UNFCCC	United Nations Framework Convention on Climate Change
USDA	U.S. Department of Agriculture
V/E	vehicles and equipment
WBCSD	World Business Council for Sustainable Development
WTE	waste-to-energy
WRI	World Resources Institute
WWTP	wastewater treatment plant

1.0   Introduction

On October 5, 2009, President Obama signed Executive Order (EO) 13514 to establish an integrated strategy towards sustainability throughout the Federal government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies. Among other provisions, EO 13514 requires agencies to "measure, report, and reduce their greenhouse gas emissions from direct and indirect activities." Section 9 of EO 13514 specifically directs the Department of Energy's Federal Energy Management Program, in coordination with the Environmental Protection Agency (EPA), the Department of Defense (DoD), the General Services Administration (GSA), the Department of the Interior (DOI), the Department of Commerce (DOC), and other agencies as appropriate, to develop recommended Federal GHG reporting and accounting procedures. Based on those recommendations, the Council on Environmental Quality (CEQ), in coordination with the Office of Management and Budget (OMB), issues its mandatory guidance for agencies to use in carrying out their GHG accounting and reporting obligations.

1.1.   Federal GHG Accounting and Reporting Guidance

The Federal GHG Accounting and Reporting Guidance (or Guidance) establishes the government-wide requirements to assist Federal agencies in calculating and reporting GHG emissions associated with agency operations. By following the Guidance and its subsequent revisions, individual agencies and the Federal government as a whole will be able to consistently track progress against GHG reduction goals. **This Technical Support Document supplements the Guidance with detailed information on the inventory reporting process, reporting requirements, and calculation methodologies**.

1.2.   Technical Support Document

This Technical Support Document accomplishes the following:

- Describes the function of the GHG Reporting Portal
- Outlines the qualitative data content required for GHG reporting
- Defines the minimum required data inputs for scope 1, 2, and 3 emission categories
- Establishes the "minimum required" and "detailed" methodologies for calculating scope 1, scope 2, specified scope 3, and other emissions (Appendices A-C)
- Provides emissions factors used in calculation methodologies for scope 1, 2, and 3 emissions (Appendix D)

2.0   Reporting GHG Emissions

The purpose of this chapter is to communicate the GHG reporting process, requirements for qualitative and quantitative data, and the use of emission factors in this Technical Support Document. The appendices in this document provide the methodologies and emission factors necessary to calculate an agencies' GHG inventory.

2.1.   Reporting Process

The reporting process is based upon the principles and structure elaborated in Chapter 5 of the Guidance. Agencies are to prepare their FY 2008 and FY 2010 inventories for submission via the GHG reporting portal. Agency inventories are to use the elaborated reporting approach and, at a minimum, provide the minimum required data elements as outlined in Section 2.3.

Electronic GHG Reporting Portal

Section 9(b) of EO 13514 requires DOE, in coordination with other agencies, to provide the necessary electronic reporting capability so that agencies can report their GHG inventories in a consistent and accurate manner. This reporting capability, or GHG reporting portal, shall be operational by October 5, 2010 as required by EO 13514. FEMP will host and maintain this electronic reporting portal, and make it freely available for agency use. Agencies shall use this reporting portal to submit their GHG inventories.

The GHG reporting portal will accurately represent current GHG reporting requirements and **provide GHG calculation functionality for the minimum required data described below and in Section 2.3**. Current FEMP energy reports will be integrated into this portal to reduce the reporting burden for agencies. Data residing in the FAST database will automatically be transferred to the GHG reporting portal, and FEMP will work to enable data sharing with other relevant Federal data systems. FEMP will provide training and other support tools to facilitate agency access to the GHG reporting portal. FEMP will also provide agencies with a spreadsheet-based data entry and calculation aid to assist with the preparation of the GHG report.

Reporting Approach

Emission categories are broken down into <u>required reporting</u> and <u>optional reporting</u>, as summarized in Chapter 2 of the Guidance. For each of the required categories, there exists a calculation methodology that allows for the "**minimum required**" data to be entered into the GHG reporting portal. If using the minimum required methodology, agencies must input activity level data, some of which can be leveraged from existing programs and collection systems (e.g., FEMP Energy Reporting, FAST database). Calculation methodologies and emission factors are embedded into the reporting portal and will automatically calculate GHG emissions associated with the reported activity data.

For many emission categories, "**detailed**" methodologies are also available, which can provide more accurate GHG accounting. Agencies may report using these detailed methodologies *instead* of the minimum required methodologies, but it is not required. As agencies become more familiar with GHG reporting, they are encouraged to utilize the detailed methodologies. To the greatest extent feasible, the reporting portal will also automatically calculate emissions based on the type of activity data entered. If the portal does not provide this function for a detailed methodology, agencies will need to enter the emission quantities expressed in units of metric tons for each GHG emitted. Detailed methodologies are included in the Technical Support Document.

For required emission categories, agencies must report using either the minimum required methodology or detailed methodology. As noted in Chapter 2 of the Guidance, there are also **optional** reporting categories, including some scope 3 emissions and specified land-use and agricultural emissions. The reporting portal does not automatically calculate emissions from these categories based on entered activity level data.

Detailed Calculations: Landfills

To illustrate how a detailed methodology might be used, consider an agency that manages a total of five landfills at different facilities, all of which are maintained and reported as part of the facilities' Clean Air Act (CAA) Title V permits. The agency's GHG lead works with each facility's Air Program Manager to determine the site-specific variables for each landfill are already readily available. During this process, the agency determines that the landfills have been closed for several decades and emit lower amounts of CH_4 than when using the Scope 1 minimum required methodology. Given that the data is available, the agency GHG lead chooses to use detailed GHG calculation methodology to calculate each of the five landfill's respective emissions and to report the total metric tons of CH_4 emissions under the Solid Waste / Landfill emission category in the GHG reporting portal.

2.2.   Reporting Qualitative Content

The GHG report content can be broken down into qualitative and quantitative emissions inventory data. This section includes the qualitative information that agencies shall report into the GHG reporting portal. These requirements are summarized in Table 2-1.

Table 2-1: GHG Inventory Qualitative Reporting Requirements

Qualitative Reporting Category	Required Information
Agency Reporting Points of Contact (POCs)	• Agency • POC information of agency staff responsible for GHG inventory
Reporting Period Information	• Fiscal year • Number of employees (optional) • Number of square feet of buildings (optional)
Allowable Exclusions from the Target	• Emissions excluded from the target • Justification for excluded emissions
Inventory Calculations for Current Reporting Year	• Emission categories inventoried • Data sources and uncertainty in data quality • Tools and calculation methodologies used, if applicable
Changes in GHG Inventory	• Description of changes since prior reporting period
Verification and Validation	• Description of verification and validation procedures completed • Inventory Management Plan, if available • Known or potential double-counting • Second-party or Third-party verifier, if applicable
Other Information	• Other information as necessary to explain report

Agency Reporting POC

Each agency Senior Sustainability Officer is ultimately responsible for submitting the agency GHG inventory and certifying the accuracy of information submitted. The agency POC information submitted should be that of the agency staff that should be contacted in case of any questions.

Reporting Period Information

Identify the fiscal year of the data reported. Agencies may optionally report their number of employees and facility square footage data to facilitate data analysis and normalization. This data may also be necessary depending on which calculation methodologies an agency chooses to adopt.

Allowable Exclusions from the Target

If an agency chooses to exclude emissions, the agency shall justify this decision. Agencies shall report these excluded emission sources separately in the GHG reporting portal because they are not excluded from the comprehensive GHG inventory. Agencies shall indicate whether there has been any change in the determination of excluded emissions from previous reporting periods.

Inventory Calculations for Current Reporting Year

For each emissions category, the agency shall describe:

- Whether the emissions were calculated;
- Any material discrepancies in the data;
- Sources of data used;
- Any uncertainty in data quality; [1] and
- Any additional tools or methodologies that were utilized.

Changes in GHG Inventory

Agencies shall discuss the degree to which the following list of potential changes from the prior reporting year has impacted their inventory.[2] Agencies should also explain the key reasons for these changes.

1. Changes in calculation or estimation methods: Where an agency chooses to use a "detailed" methodology, the agency shall indicate which methodology it applied. Since any changes in methodology from year to year can affect the accuracy of the emissions estimate, the agency shall indicate whenever calculation methodologies change and estimate the impact of that change. If an agency wants to employ a different methodology from that stipulated in the Guidance or this Technical Support Document, this must first be discussed with CEQ.

2. Changes in organizational boundary: Describe how the list of exclusions and exemptions reported, as well as other factors may have changed the agency's organizational boundary

3. Base year and subsequent year recalculation: Summarize changes in base year and subsequent year calculations (see Section 5.4). Agencies can also describe how any adjustments emissions factors, especially eGRID, affected their past inventories.

4. Other changes in emissions: Agencies may summarize other changes in emissions that did not trigger a base year recalculation.

5. Anticipated changes for next reporting period: Indicate any known or anticipated changes in organizational boundaries in future years that may affect the inventory. For instance, agency missions may change or temporary, planned changes in operations may lead to significant impacts on their GHG emissions. Agencies should report such changes to the extent they consider them relevant to understanding the high level summary and trends of emissions reported.

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[1] Both the utility and accuracy of a GHG emissions report depends upon the quality of the data available. Agencies should give particular attention to any data problems, including missing data, means used to evaluate data quality and procedures used to ensure the accuracy of the data.

[2] For FY 2010 reporting, agencies should compare to their FY 2008 inventory, where applicable.

Verification and Validation

Agencies shall discuss their approach for verification and validation, and if there is any foreseen change in this approach for the next reporting year. Agencies can reference a separate inventory management plan, if applicable. Agencies should also acknowledge any known or potential double counting. If an agency used second-party or third-party verification, the verifier name, position, and contact information must be listed. See Chapter 6 of the Guidance for more information on verification and validation.

2.3.   Quantitative Inventory Data Requirements

Agencies shall report the activity data inputs and/or GHG emissions to the GHG reporting portal. This section lists the "minimum required" data elements for reporting scope 1, 2, and 3 emissions, as well as other emissions. Data reported by the agency shall be summed to the highest level within the agency across all components of the agency.

Agencies shall maintain records of these data inputs and GHG emissions that are summed to the highest level appropriate to the calculation method applied. For example, if the data available for an agency requires the use of different methodologies for parts of the same emissions category, the agency shall report separate data under the different methodologies. The sum of the emissions would be calculated automatically by the portal for that emissions category.

Required Scope 1 Data

Agencies shall report scope 1 emissions in four major categories: stationary combustion, mobile combustion, fugitive emissions and process emissions. Agencies that do not have any process emissions shall provide a positive statement that emissions are not applicable in that category.

All agency scope 1 stationary and mobile emissions data are to be reported in units as indicated in the 'minimum required data' column of Table 2-2. The GHG reporting portal will calculate GHG emissions for each GHG and the total CO_2e from each of the reported data elements in the minimum required methodology. Agencies shall report the fuel use and total of each GHG emitted if using the detailed method for mobile sources. Because agencies will also be using the reporting portal for EISA energy reporting, they must report goal-subject (GS) energy, goal-excluded (GE) energy, non-fleet vehicles and equipment (V/E), and fleet vehicle emissions separately according to the definitions previously established under EPAct05, EO13423, and EISA.[3]

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[3] Report CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 by GHG, by GHG in CO_2e, and as total CO_2e for scopes 1, 2, and 3 and other non-scope emissions and their subcategories.

Table 2-2: Data Needed for Required Reporting: Scope 1 Emissions from Combustion

Emissions Category	Minimum Required Data	Current Reporting	Detailed Methodology Available?
Stationary Combustion (Agency owned and controlled heat and steam)	• GS or GE for natural gas • Volume [KCUFT] or energy content [BBtu]	• FEMP Annual Energy Report	No
	• GS or GE for fuel oil, gasoline, and/or LPG/propane • Volume [KGal] or energy content [BBtu]	• FEMP Annual Energy Report	No
	• GS and GE for coal and/or other (MSW) • Mass [Short Ton] or energy content [BBtu]	• FEMP Annual Energy Report	No
	• GS and GE for biofuels and/or biomass • Volume [KCUFT or KGal], mass [Short Ton], or energy content [BBtu]	• FEMP Annual Energy Report	No
Mobile Fossil Fuel (Agency owned and controlled vehicles, airplanes, etc.)	• Fleet and V/E for compressed natural gas, gasoline, diesel, LPG/propane, aviation gas, jet fuel, navy special, and/or other • Volume [KCUFT or KGal], or energy content [BBtu]	• FAST System • FEMP Annual Energy Report	Yes
	• Fleet and V/E for E85, biodiesel (B20), biodiesel (B100) • Biofuel content (e.g., % ethanol) • Volume [KGal] or energy content [BBtu]	• FAST System • FEMP Annual Energy Report	Yes

Fugitive Emissions

All agency scope 1 fugitive emissions data are to be reported in units as indicated in the 'minimum required data' column of Table 2-3. The GHG reporting portal will calculate GHG emissions for each GHG and the total CO_2e from each of the reported data elements in the minimum required methodology. Agencies shall calculate emissions using the appropriate minimum required or detailed methodologies. If detailed methodologies are used, the agency scope 1 fugitive emissions are to be reported in units of metric tons for each GHG emitted. The reporting portal will convert these emissions into CO_2e.

Table 2-3: Data Needed for Required Reporting: Scope 1 Fugitive Emissions

Emissions Category	Minimum Required Data	Current Reporting	Detailed Methodology Available?
Fluorinated Gases (HFCs, PFCs, SF$_6$)	• Mixed refrigerant or F-gas material type • Amount charged or issued [Pounds] • Amount returned to the supply system, including recovered from equipment [Pounds]	• Facility Title V Reporting	Yes
Wastewater treatment	• Population served	• Facility Title V Reporting	Yes
Solid waste/ Landfill	• Mass of solid waste disposed [Short Ton] • Landfill open date • Landfill close date	• Facility Title V Reporting • EO 13423 & EO 13514 Solid Waste & Diversion Reporting	Yes
Others	• Agency and facility specific data required	• Facility Title V, MRR, and/or Emergency Planning and Community Right-To-Know Act (EPCRA) Reporting	Yes

Process Emissions

All agency scope 1 process emissions are to be reported in units of metric tons per GHG type emitted. The reporting portal will convert these emissions into CO_2e. Data requirements for the calculation methodology are provided in Appendix A. As process emissions are site- and process-specific, there is no minimum required methodology. If agencies have process emissions for which the list of methodology references is not applicable, they may consult with FEMP to identify an appropriate methodology.

Some agencies may find that supporting data on their process emissions is already used to prepare their reports under the EPCRA 313, the Toxic Release Inventory (TRI) Program, or the MRR. Agencies are encouraged to leverage data directly from their TRI data collection and calculation efforts, as appropriate.

Required Scope 2 Data

Major Emissions Categories

Agencies shall report emissions in five major categories: purchased electricity, purchased steam, purchased hot water or chilled water, combined heat and power, and waste-to-energy purchased steam. When reporting combined heat and power, agencies shall use the appropriate method depending on whether the agency purchased electricity, steam and/or hot water. All agency

scope 2 emissions data are to be reported in units as indicated in the 'minimum required data' column of Table 2-4.

Agencies shall track and report the requisite data separately for each calculation methodology. **For purchased electricity, data shall be reported separately for each eGRID subregion** and emissions will be calculated by the GHG portal using the most recent eGRID subregion emissions factors. Because agencies will also be using the reporting portal for EISA energy reporting, they must report GS and GE energy separately according to the definitions previously established under EPAct05, EO 13423, and EISA.

FEMP shall use the same data classifications as the existing federal energy report to the extent possible. If agencies utilize the minimum required category, the GHG portal will calculate GHG emissions for each GHG and the total CO_2e based upon the reported data. Otherwise, the data entered into the detailed methodology categories should consist of both the energy used and the metric tons for each GHG emitted.

Renewable Energy and RECs

Agencies shall separately report purchased renewable energy, including renewable energy certificates (RECs), that are being used to reduce scope 2 emissions. Reporting must be consistent with existing renewable energy guidance and Chapter 4 of the Guidance. Agencies shall provide the following information related to all RECs purchased:

1. Source/Type
2. Location or eGRID subregion
3. Size (Amount of MWh, BBtu, etc)
4. If the generator is on-site, and if so whether the generator is on the agency side of meter, separately metered, or off-grid

The eGRID emission factors will be embedded in the reporting portal, so the CO_2e of each REC purchased will be automatically calculated.

Table 2-4: Data Needed for Required Reporting: Scope 2 Emissions

Emissions Category	Minimum Required Data	Current Reporting	Detailed Methodology Available?
Purchased Electricity	• GS and GE electricity consumed [MWh] by eGRID subregion and U.S Territory	• FEMP Annual Energy Report (*Note: requires new level of disaggregated data to eGRID subregion*)	Yes
Purchased Steam, Hot Water, or Chilled Water	• Steam or hot water consumed [BBtu] • Cooling demand [BBtu or Ton Hours]	• FEMP Annual Energy Report	Yes
Combined Heating and Power	• GS and GE electricity consumed [MWh] by eGRID subregion • Steam or hot water consumption [BBtu]	• FEMP Annual Energy Report (*Note: requires new source location information to eGRID subregion level*)	Yes
Purchased Steam from Waste-To-Energy	• Steam consumed [BBtu] • Default eGRID derived emission factors	• FEMP Annual Energy Report	Yes
Renewable Power Purchases	• Renewable power purchased [MWh] • eGRID subregion(s) in which the renewable energy was generated • Generator on- or off-agency site and whether on agency side of meter, separately metered, or off-grid	• FEMP Annual Energy Report (*Note: requires new source location information to eGRID subregion level*)	Yes
REC Purchases	• Amount [MWh] of RECs purchased by source and location/eGRID region • Generator on- or off-agency site and whether on agency side of meter, separately metered, or off-grid	• FEMP Annual Energy Report (*Note: requires new source location information to eGRID subregion level*)	Yes

Required Scope 3 Data

Agencies shall report three scope 3 categories: (1) business air travel, (2) T&D losses for electric, steam, and chilled water use, and (3) contracted solid waste disposal. For business air travel, agencies shall coordinate with GSA and their travel agent to ensure data is reported into their database (see Appendix C for additional detail.). T&D losses will be automatically

calculated using the reporting portal because emissions are based on the emission factors for scope 2 data already submitted. For contracted solid waste, the reporting portal will use the tons disposed and the default values provided in Appendix C for the minimum required methodology. Agencies may alternatively coordinate with their waste contractors for site-specific emission factors. If using the detailed methodologies, agency scope 3 emissions shall be reported in units of metric tons for each GHG type emitted.

Table 2-5: Data Needed for Required Reporting: Scope 3 Emissions

Emissions Category	Minimum Required Data	Current Reporting	Detailed Methodology Available?
Business Air Travel	• Passenger Name Record (PNR) from Travel Agent sent to GSA	• PNRs currently submitted to GSA • Agency Travel Reporting	No
T&D Losses	• Purchased electricity [MWh] • Purchased steam or hot water [BBtu] • Purchased chilled water [BBtu]	• FEMP Annual Energy Report	No
Contracted Solid Waste Disposal	• Municipal solid waste disposed [Tons]	• EO 13423 & EO 13514 Solid Waste and Diversion Reporting	Yes

Biogenic Emissions Reporting

As discussed in Chapter 3 of the Guidance, biogenic emissions are accounted for separately from scope 1, scope 2, and scope 3. Biogenic CO_2 emissions are generated during the combustion of biofuels and biomass. Agencies are required to report the biogenic CO_2 emissions generated by these combustion activities, where data is available. While biogenic CO_2 emissions are reported as a required part of their GHG inventory, they do not count against their GHG reduction target.

The GHG reporting portal will automatically calculate scope 1 emissions (i.e., CH_4, N_2O, and CO_2 from the fossil fuel portion of biofuel blends) from biogenic sources based on the agencies' reported biogenic renewable energy use. Agencies using detailed methodologies should ensure they calculate and report biogenic emissions in those categories, as applicable.

2.4. Optional Reporting Categories

Agencies must differentiate between GHG emissions data that are required by the Guidance and those that go beyond the requirements. Optional reporting currently focuses on international and other excluded by the EO, land use and agricultural, various categories of scope 3, and GHGs not covered by the EO.

Optional Scope 3 Reporting

Agencies may report additional scope 3 categories. Along with the required scope 3 categories, calculation methodologies for ground business travel, employee commuting, and contracted wastewater treatment are also provided in Appendix C. It is important to note that ground business travel, employee commuting, and contracted wastewater treatment will all be required scope 3 reporting effective FY 2011.

For ground business travel (e.g., rail, bus, rental vehicle), agencies should coordinate with their travel agents and accounting departments to determine data availability. Information on commuter travel can come either from national or regional travel survey data for the minimum required category or be generated through an agency- or site-specific commuter surveys using the detailed methodology. Agencies should coordinate with their facilities to investigate the availability of commuter data and/or existing surveys. For contracted wastewater treatment, the GHG reporting portal will use the number of employees served and the default values provided in Appendix C for the minimum required methodology. Agencies may alternatively coordinate with their facility-specific provider for the variables necessary to calculate detailed emission estimates.

Table 2-6: Data Needed for Optional Scope 3 Reporting

Emissions Category	Optional Categories	Minimum Required Data	Detailed Methodology Available?
Ground Business Travel	Optional Scope 3	• Mode of transportation • Distance-traveled data, in miles	Yes
Commuter Travel	Optional Scope 3	• Number of commuters • Regional / National transportation survey factors (U.S. Census Bureau, Center for Neighborhood Technology)	Yes
Contracted Wastewater Treatment	• Number of employees served	• Agency Employee Reporting	Yes

Agencies may also report additional scope 3 emissions (e.g. vendor and supplier emissions) or agency-specific scope 3 emissions that are unique to their agency operations. Agencies should coordinate with FEMP on the proposed methodologies to be used for all scope 3 categories if different than either the minimum required or detailed methodologies. All agency scope 3 emissions shall be reported in units of metric tons for each GHG type emitted.

Agencies may report other emission categories at their discretion. These categories may include:

- Enteric fermentation and manure management

- Ozone Depleting Substance (ODS)

- Non-Kyoto GHGs (e.g., NF_3)

FEMP will provide functionality in the GHG reporting portal to support optional reporting.

2.5. Emission and Conversion Factors

To ensure accurate GHG inventories, it is vital to apply appropriate emission and conversion factors consistently across the government. This section describes the factors used in the minimum required calculation methodologies. As necessary, this document will be revised by September 30 of each reporting year to incorporate the most accurate calculation methodologies and emission factors available.

Emission Factor and Calculation Methodology Selection

Emission factors and methodologies referenced in this Guidance were selected because of their applicability to Federal operations, technical authority, and acceptance in other GHG reporting programs. Calculation methods and emission factors were leveraged from existing GHG regulatory and voluntary inventory protocols, with the MRR given top priority when applicable, followed by other U.S. Federal sources. Emission factors and methodologies were selected from the following sources:

1. U.S. EPA, Mandatory Greenhouse Gas Reporting Rule (MRR), Federal Register, Friday, October 30, 2009, See at:
   http://www.epa.gov/climatechange/emissions/ghgrulemaking.html

2. U.S. EPA, Climate Leaders Program, Technical Guidance, See at:
   http://www.epa.gov/stateply/resources/index.html

3. U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks, See at:
   http://www.epa.gov/climatechange/emissions/usinventoryreport.html

4. U.S. EPA, Clean Energy Program, eGRID Tool Methods, See at:
   http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

5. U.S. DOE, 1605(b) Voluntary Reporting of Greenhouse Gases Program, Technical Guidelines, See at: http://www.eia.doe.gov/oiaf/1605/gdlins.html

6. International Panel on Climate Change (IPCC), 2006 Guidelines for National Greenhouse Gas Inventories, See at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html

Emission and Conversion Factor Sources

Emission and conversion factor sources used throughout this Technical Support summarized in

Table 2-7:

Table 2-7: Emission and Conversion Factor Sources

Applicable Scope	Emissions Categories	Factor Type	Minimum Required Methodology Emission Factor Source	Detailed Methodology Applicable
All Scopes and Optional	All Emission Categories	Global Warming Potentials	U.S. EPA MRR, Table A-1 to Subpart A of Part 98	YES
		Conversion Factors	U.S. EPA MRR, Table A-2 to Subpart A of Part 98	YES
Scope 1 and Biogenic	Stationary Combustion (Agency owned and controlled heat and steam)	CO_2 Emission Factors and High Heat Values for Various Types of Fuel	U.S. EPA MRR, Table C-1 to Subpart C of Part 98	YES
		CH_4 and N_2O Emission Factors for Various Types of Fuel	U.S. EPA MRR, Table C-1 to Subpart C of Part 98	Equipment-Specific
	Mobile Combustion (Agency owned and controlled vehicles, airplanes, etc.)	CO_2 Emission Factors and High Heat Values for Various Types of Fuel	U.S. EPA MRR, Table C-1 to Subpart C of Part 98	YES
		CH_4 and N_2O Emission Factors for Various Types of Fuel	U.S. EPA MRR, Table C-1 to Subpart C of Part 98	Vehicle-Specific
Scope 1 and Scope 3	Solid Waste / Landfill	Emission Model Equation Defaults	U.S. EPA MRR, Table HH-1 to Subpart H of Part 98 and LANDGEM	YES but Site-Specific
	Wastewater Treatment	CH4 Emission Factors / Model	U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks	YES but Site-Specific
Scope 2	Purchased Electricity	CO_2, CH_4 and N_2O Emission Factors by eGRID Subregion	U.S. EPA, eGRID Program, Emission Rate Summary Tables and DOE 1605(b) Emission Factors	N/A
	Purchased Steam or Hot Water	CO_2, CH_4 and N_2O Emission Factors	DOE 1605(b), Technical Guidelines	NO Plant-Specific
	Chilled Water	CO_2, CH_4 and N_2O Emission Factors	DOE 1605(b), Technical Guidelines	NO Plant-Specific
	Combined Heating and Power	Electricity, Steam, and Hot Water CO_2, CH_4 and N_2O Emission Factors	U.S. EPA, eGRID Program, Emission Rate Summary Tables and DOE 1605(b), Technical	NO Plant-Specific

Applicable Scope	Emissions Categories	Factor Type	Minimum Required Methodology Emission Factor Source	Detailed Methodology Applicable
			Guidelines	
	Purchased Steam from Waste-To-Energy	Steam CO_2, CH_4 and N_2O Emission Factors	U.S. EPA, eGRID Program Derived	NO Plant-Specific
	Renewable Power Purchases	CO_2, CH_4 and N_2O Emission Factors by NERC Subregion	U.S. EPA, eGRID Program, Emission Rate Summary Tables	YES
Scope 3	T&D Losses	Loss Factors	U.S. EPA eGRID Program and DOE 1605(b), Technical Guidelines	N/A
Optional	Ground Business Travel	Vehicle CO_2, CH_4 and N_2O Emission Factors	U.S. EPA Climate Leaders, Optional Emissions Guidance	YES
	Commuter Travel	Public Transit CO_2, CH_4, and N_2O Emission Factors		YES

Scope 2 Emission Factors and Reporting

For scope 2 electricity, the GHG reporting portal will use the eGRID subregion emission factors provided by the U.S. EPA eGRID database to calculate minimum required category GHG emissions. This database divides the electric grid into 26 subregions with unique emission factors based on the regional electricity generation mix. Figure 2-1 shows the eGRID subregions.

Agencies are responsible for reporting their electricity usage according to these regions. Agencies can map a facility's zip code to the corresponding eGRID subregion using the EPA Power Profiler website.[4] If an agency cannot map FY 2008 electricity data by region, percentage factors determined from the FY 2010 electricity usage may be applied to the FY 2008 consumption to allocate this usage. Agencies reporting facilities in U.S. territories or foreign nations should use emission factors from DOE 1605(b) Technical Guidance Emission Factors.[5]

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[4] U.S. EPA Power Profiler. See at: http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html.
[5] U.S. DOE 1605(b) Emission Factors. See at: http://www.eia.doe.gov/oiaf/1605/emission_factors.html.

Figure 2-1: eGRID Subregions
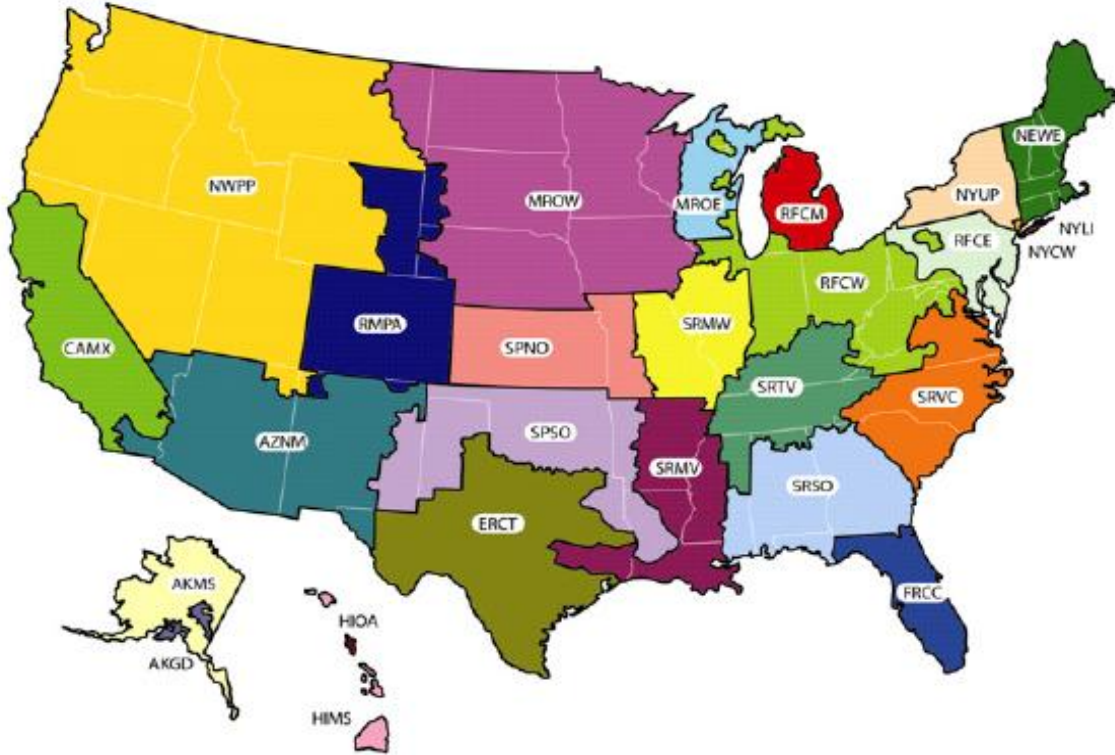
Appendix A – Calculating Scope 1 Emissions

This appendix describes the scope 1 emission sources most commonly operated by Federal agencies, as well as required data, recommended data sources, and the minimum required and detailed calculation methodologies.

This appendix provides calculation methodologies for:

- Stationary Combustion: Electricity, Heating, Cooling, Steam
- Mobile Combustion: Fossil Fuels
- Mobile Combustion: Biofuel
- Biomass Combustion
- Fugitive Emissions
- Wastewater Treatment
- Landfills and Solid Waste Facilities
- Industrial Process Emissions

A.1 Stationary Combustion: Electricity, Heating, Cooling, Steam

Description

Scope 1 Stationary Combustion emissions result from generation of electricity, heat or steam from sources owned and controlled by the agency. This includes emissions from use of boilers, furnaces, turbines and emergency generators.

A.1.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

The minimum required methodology is a fuel use method, rather than direct emissions monitoring (i.e., continuous emissions monitoring) or a mass balance method (direct sampling), since fuel use is already tracked and reported to FEMP annually. In the EPA MRR, this is a Tier 1 method. If a source is not currently reported to FEMP but within the agencies' operational control, this data may also be available in bulk fuel or delivery receipts, contract or agency purchase records, stock inventory documentation, or maintenance records on turbines/emergency generators, furnaces and boilers.

Table A-1: Stationary Combustion Minimum Required Data Sources

Data Element	Preferred Source
Electricity generation: Total amount of natural gas, diesel, gasoline, propane, and other fuels consumed by generator and/or turbines	• Annual energy reporting to FEMP
Heat: Total amount of fuels consumed by furnace	• See Above

Steam production: Total amount of fuels consumed	• See Above
Emission Factor	• See Table D-1

Calculation Steps[6]

The methodology used to calculate scope 1 emissions from stationary combustion is described below. Using the minimum required methodology, agencies only need to enter the activity data from step 1 into the GHG reporting portal:

1. Determine amount of fuel consumed annually

2. Determine the appropriate CO_2 emission factors for each fuel

3. Determine the appropriate CH_4 and N_2O emission factors for each fuel

4. Calculate each fuel's CO_2 emissions

5. Calculate each fuel's CH_4 and N_2O emissions

6. Convert CH_4 and N_2O emissions to metric tons (MT) CO_2e and determine total emissions

Step 1: Determine amount of fuel consumed annually

Identify all fuels combusted at the agency's facilities. Much of this data should already be collected and reported at the agency level in the Annual Energy Report to FEMP. Convert the fuel use data from physical units (mass or volume) to energy units (million BTU, or MMBtu) using the High Heat Values available in Appendix D.[7]

Fuel consumed (MMBtu) = Fuel consumed (units of fuel type) ● High Heat Value (MMBtu/units of fuel type)

Step 2: Determine the appropriate CO_2 emission factors for each fuel

The emission factors for CO_2 by fuel are represented in kg CO_2e/MMBtu. See Appendix D for a complete list of emissions factors by fuel.

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel

CH_4 and N_2O emissions can be estimated based on fuel type emissions factors, as recommended here and used by the GHG reporting portal. However, agencies can calculate

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[6] Primary reference: US EPA, Technical Support Document (TSD) for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases (MRR), 40 CFR part 98, Subpart C, 30 January 2009.

[7] Also see: TSD MRR Stationary Sources, 40 CFR Part 98 Subpart C, Table C-1 and C-2 for emission factors.

more site-specific emission estimations using data that considers the end-use sector (e.g., commercial, industrial) and reported under detail methodology category, when applicable.[8]

Step 4: Calculate each fuel's CO_2 emissions

Multiply annual fuel consumed (Step 1) by the emission factors for CO_2 (Step 2) in kg CO_2e/MMBtu. Convert kilograms into metric tons.

Equation A-1: Stationary Combustion CO_2[9]

CO_2 Emissions (kg) =
Fuel consumed (MMBtu) ● emission factor (kg CO_2/ MMBtu) ● 1 MT/1,000 kg

Step 5: Calculate each fuel's CH_4 and N_2O emissions

To determine CH_4 emissions, multiply fuel use from Step 1 by the CH_4 emission factor from Step 3. Convert kilograms to metric tons, Repeat the calculation for each fuel (and sector type if using default emission factor by end use).

Equation A-2: Stationary Combustion CH_4

CH_4 Emissions (MT) =
Fuel consumed (MMBtu) ● emission factor (kg CH_4/ MMBtu) ● 1 MT/1,000 kg

Equation A-3: Stationary Combustion N_2O

N_2O Emissions (MT) =
Fuel consumed (MMBtu) ● emission factor (kg N_2O/ MMBtu) ● 1 MT/1,000 kg

Step 6: Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions

Use the GWP factors found in Appendix D to convert emissions to units of CO_2e. Sum emissions from all three gases to determine total MT CO_2e.

Equation A-4: Stationary Combustion MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) =
(MT N_2O ● GWP N_2O) + (MT CH_4 ● GWP CH_4) + MT CO_2

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[8] Emission factors are also identified for specific types of combustion equipment for sites with significant stationary emissions. The Climate Registry Local Government Operations Protocol, (2008), Table G.4.
[9] For the purposes of clarity in reading the equations, the symbol ● has been used to indication multiplication instead of symbols such as "x".

Example A-1: Stationary Combustion

Step 1 - Determine amount of fuel consumed annually
1,000 CCF (hundred cubic feet) of natural gas is consumed by an agency. The default High Heat Value for natural gas is 1.028×10^{-3} MMBtu/scf. This converts to 102.8 MMBtu.

Step 2: Determine the appropriate CO_2 emission factors for each fuel
The CO_2 emissions factor for this example is 53.02 kg CO_2/MMBtu.

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel
The natural gas emissions factors for CH_4 and N_2O are 1.0×10^{-3} and 1.0×10^{-4} kg /MMBtu

Step 4: Calculate each fuel's CO_2 emissions in MT CO_2e

Equation A-1: Stationary Combustion CO_2
CO_2 (kg) = Fuel consumed (MMBtu) ● emission factor (kg CO_2/ MMBtu) ● 1 MT/1,000 kg
$\qquad$ = 102.8 MMBtu ● 53.02 kg CO_2/ MMBtu ● 1 MT/1,000 kg
$\qquad$ = 5.450 MT CO_2

Step 5: Calculate each fuel's CH_4 and N_2O emissions and convert to MT

Equation A-2: Stationary Combustion CH_4
CH_4 (MT) = Fuel consumed (MMBtu) ● emission factor (kg CH_4/ MMBtu) ● 1 MT/1,000 kg
$\qquad$ = 102.8 MMBtu ● 1.0×10^{-3} kg / MMBtu ● 1 MT/1,000 kg
$\qquad$ = 1.028×10^{-4} MT CH_4
Equation A-3: Stationary Combustion N_2O
N_2O (MT) = Fuel consumed (MMBtu) ● emission factor (kg N_2O / MMBtu) ● 1 MT/1,000 kg
$\qquad$ = 102.8 MMBtu ● 1.0×10^{-4} kg / MMBtu ● 1 MT/1,000 kg
$\qquad$ = 1.028×10^{-5} MT N_2O

Step 6: Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions

Equation A-4: Stationary Combustion MT CO_2e Emissions
CO_2e Emissions (MT CO_2e) = (MT CH_4 ● GWP CH_4) + (MT N_2O ● GWP N_2O) + MT CO_2
$\qquad$ = (1.028×10^{-3} MT CH_4 ● 21) + (1.028×10^{-5} ● 310) + 5.450
$\qquad$ = 2.159×10^{-3} + 3.187×10^{-3} + 5.450
$\qquad$ **= 5.456 MT CO_2e**

A.2 Mobile Combustion: Fossil Fuels

Description

Mobile fossil fuel emissions sources are primarily vehicle fleets, but can also come from non-road vehicles (e.g., agriculture equipment), research aircraft and waterborne vessels. Fuel types may include gasoline, diesel, aviation gas, Jet-A, and other fuels derived from fossil fuel sources.

CO_2 emissions, which account for the majority of emissions from mobile sources, can be calculated using fuel consumption data already reported to the FAST for both the minimum

required and detailed methodology. However CH_4 and N_2O emissions vary depending on emission control technologies and distance traveled. FAST data is used for the minimum required methodology but is limited to using a default value. Agencies may utilize fleet composition and fuel consumption to report under the detailed methodology category.

A.2.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

The minimum required methodology uses the data already reported to FAST and uses assumptions about the fleet to calculate CH_4 and N_2O emissions.

Table A-2: Mobile Combustion: Fossil Fuels Minimum Required Data Sources

Data Element	Preferred Source
Annual Fuel Consumption data by type (gal) [10]	• FAST database
Emission Factor	• CO_2: See Appendix D by fuel type, • CH_4 and N_2O: See Appendix D by fuel type

Calculation Steps for CO$_2$ Emissions[11]

FAST includes agency level information on fuel consumption per fuel type and vehicle types. Agencies can use this data to calculate CO_2 emissions. To calculate scope 1 CO_2 emissions from mobile combustion of fossil fuels:

1. Determine the total amount of fuel consumed by type

2. Determine the appropriate emission factors for each fuel

3. Calculate total CO_2 emissions and convert to MT CO_2e

Step 1: Determine the total amount of fuel consumed by type

FAST includes agency level information on fuel consumption per fuel type and vehicle type. The GHG reporting portal uses the following methodology to calculate scope 1 CO_2 emissions from mobile combustion of fossil fuels:

Step 2: Determine the appropriate emission factors for each fuel

A complete table of CO_2 emissions factors by fuel based on national fuel averages is located in Appendix D.

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[10] This applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For these vehicles, estimation of CH_4 and N_2O emissions is based on fuel consumption rather than distance traveled.

[11] Primary Reference: EPA Climate Leaders Technical Guidance, Direct Emissions from Mobile Combustion Sources, May 2008.

Step 3: Calculate total CO_2 emissions and convert to metric tons

To determine CO_2 emissions from mobile combustion, first multiply fuel use (Step 1) by the CO_2 emissions factor (Step 2), and then convert kilograms to metric tons.

Equation A-5: Mobile Combustion of CO_2 (Fossil Fuels)

CO_2 emissions (MT CO_2) =   Vehicle fuel consumption (gal) ● CO_2 emissions kg/gal ● 1 MT/1,000 kg

Calculation Steps for CH4 and N2O Emissions

As FAST does not correlate fuel use by type of vehicle or mileage, this methodology requires significant assumptions about the mobile inventory. This methodology intentionally overestimates the amount of CH_4 and N_2O emissions from mobile sources by using the highest gram per unit of fuel value under available control technology from 2005 for the entire fleet.[12] It is recommended to estimate mobile emissions based on a fleet of 2005 light-trucks using Low Emission Vehicle (LEV) Technology or advanced controls.

Agencies with more detail on the vehicle fleet composition connected to fuel use can choose to use the detailed calculation methodology detailed after this section, either with full data or weighted averages per vehicle and fuel type.

To calculate scope 1 CH_4 and N_2O emissions from mobile combustion of fossil fuels:

1. Determine the total amount of fuel consumed by type

2. Determine the average miles per gallon of the fleet in 2005 (17.2 mpg)

3. Determine the appropriate emission factors for fuel and vehicle type

4. Convert the emissions factor from g/mile to kg/gal of fuel

5. Calculate CH_4 and N_2O emissions by fuel type and sum

6. Determine the total annual MT CO_2e

Step 1: Determine the total amount of fuel consumed by type

Agencies should use the data already reported to FAST. If data is available, the agency can pursue the detailed methodology and estimate fuel use by vehicle activity data, fuel economy factors, or dollars spent. Purchase units must be converted into gallons.

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[12] 2005 is used because GSA leases are for 5 years, choosing the earliest year. While agency-owned vehicles may be significantly older, there will also be a percentage that is newer. In 2005, the majority of all vehicles were Tier 2 Control Technologies, so this approach uses the second largest (and more conservative) group - Low Emissions Vehicles and advanced control mechanisms. The average model year CH_4 and N_2O emissions in 2005 did not vary significantly since 2001.

Step 2: Determine the average miles per gallon of the fleet in 2005 (17.2 mpg)

The average truck in 2005 got 17.2 miles per gallon combined.[13] This calculation should solely be used for of the minimum required CH_4 and N_2O emissions estimates, as it is intentionally overestimated.

Step 3: Determine the appropriate emission factors for fuel and vehicle type

It is a required minimum procedure, and recommended, to use the highest g/mile emissions factor for each fuel during the year 2005 and assume this is standard across the entire fleet. For each fuel, use the light truck LEV or advanced technology emission factors. For example, the emissions factors for a gasoline light-duty truck with LEV technology are 0.0157 g N_2O/mile and 0.0148 g CH_4/mile. See Appendix D[14].

Step 4: Convert the emissions factor from g/mile to g/gal of fuel

Multiply the CH_4 and N_2O emission factors in g/mile by the average miles per gallon identified in Step 2 (17.2 mpg) to find g/gal of fuel.

Step 5: Calculate CH_4 and N_2O emissions by fuel type and sum

Use Equation A-5, substituting the new CH_4 and N_2O emission factors found in Step 4 for each fuel type. Convert to kg/gal, when necessary.

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[13] US EPA, Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2009, Appendix D, Table D-7 – Characteristics of 1975 to 2009 Trucks; http://www.epa.gov/oms/fetrends.htm.

[14] US EPA Climate Leaders Mobile Combustion Sources, May 2008, Table A-1, A-6, A-7.

Example A-2: Mobile Combustion (Fossil Fuels) – Minimum Required Methodology

CO_2 Step 1: Determine the total amount of fuel consumed by type
The agency fleet consumed 500,000 gallons of gasoline.

CO_2 Step.2: Determine the appropriate emission factors for each fuel
The CO_2 high heat value for motor gasoline is 0.125 MMBtu/gal. When multiplied by the default CO_2 emission factor of 70.22 kg CO_2/MMBtu, the emission factor is 8.78 kg CO_2/gal.

CO_2 Step 3: Calculate total CO_2 emissions and convert to MT CO_2e

Equation A-5: CO_2 emissions
Gasoline CO_2 emissions = Vehicle fuel consumption ● CO_2 emissions/gal ● 1 MT/1,000 kg
= 500,000 gal ● 8.78 kg CO_2/gal ● 1 MT/1,000 kg
= 4,388.75 MT CO_2

CH_4 and N_2O Step 1: Determine the total amount of fuel consumed by type
The agency fleet consumed 500,000 gallons of gasoline.

CH_4 and N_2O Step 2: Determine the average miles per gallon of the fleet in 2005
The default type of vehicle is capable of 17.2 mpg.

CH_4 and N_2O Step 3: Determine the appropriate emission factors for fuel and vehicle type
The default emissions factors for the default vehicle (light truck, LEV technology, 2005) are 0.0157 g N_2O/mile and 0.0148 g CH_4/mile.

CH_4 and N_2O Step 4: Convert the emissions factor from g/mile to kg/gal of fuel

0.0148 g CH_4/mile ● 17.2 miles/gal ● 1 kg/1,000 g = 2.55 x 10^{-4} kg CH_4/gal
0.0157 g N_2O/mile ● 17.2 miles/gal ● 1 kg/1,000 g = 2.70 x 10^{-4} kg N_2O /gal

CH_4 and N_2O Step 5: Calculate CH_4 and N_2O emissions by fuel type and sum

Equation A-5: CH_4 and N_2O emissions
Gasoline CH_4 emissions = Vehicle fuel consumption ● kg CH_4 emissions/gal ● 1 MT/1,000 kg
= 500,000 gal ● 2.55 x 10^{-4} kg CH_4/gal ● 1 MT/1,000 kg
= 0.128 MT CH_4
Gasoline N_2O emissions = Vehicle fuel consumption ● kg N_2O emissions/gal ● 1 MT/1,000 kg
= 500,000 gal ● 2.70 x 10^{-4} kg N_2O /gal ● 1 MT/1,000 kg
= 0.135 MT N_2O

CH_4 and N_2O Step 6: Determine the total annual MT CO_2e

Equation A-7: CO_2 equivalent emissions
Gasoline CO_2 emissions = 4,388.75 MT CO_2
Gasoline CH_4 emissions = MT CH_4 ● GWP CH_4
= 0.128 MT CH_4 ● 21
= 2.68 MT CO_2e
Gasoline N_2O emissions = MT N_2O ● GWP N_2O
= 0.135 MT ● 310
= 41.85 MT CO_2e
Total CO_2e emissions = 4,388.75 + 2.68 + 41.85
= 4,433.28 MT CO_2e

A.2.2 Detailed Methodology (User Calculated)

Data Sources

The detailed calculation methodology uses data on annual mileage and fleet composition to find fleet-specific emissions totals.

Table A-3: Mobile Combustion: Fossil Fuels Detailed Data Sources

Data Element	Preferred Source	Alternate Source
Annual Fuel Consumption data by type (gal)	- FAST database - Operating and Support Management Information System (OSMIS) database - Agency non-fleet vehicles/equipment records	- Dollars spent on fuel and average price per gallon - Annual mileage and vehicle fuel economy reported
CH_4 and N_2O: Annual mileage by vehicle type, emission control technology and fuel type[15]	Miles traveled data	- Miles traveled estimates based on hours traveled and fuel economy - Weighted average percentages of vehicle type and efficiency data from vehicle population
Emission Factor	CO_2: See Appendix D by fuel type, CH_4 and N_2O: See Appendix D by fuel type, vehicle type, and combustion technology	See Minimum Required

Calculation Steps for CO2 Emissions

See the Minimum Required Methodology for CO_2 emissions.

Calculation Steps for CH4 and N2O Emissions

Agencies can choose this methodology if there is data on fleet mileage by specific control technologies. Alternatively, if data on specific control technologies are not available, or are too labor intensive to generate, agencies can estimate CH_4 and N_2O emissions using a weighted average of available control technologies by model year and apply the sums to the detailed calculation methodology (see Appendix D for average emission factors).

To calculate scope 1 CH_4 and N_2O emissions from mobile combustion of fossil fuels:

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[15] This applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For these vehicles, estimation of CH_4 and N_2O emissions is based on fuel consumption rather than distance traveled.

1. Identify the vehicle type, fuel type, and technology type of all the vehicles

2. Determine mileage by vehicle type

3. Determine the appropriate emission factors for fuel and vehicle type

4. Calculate CH_4 and N_2O emissions by vehicle type and sum

5. Determine the total annual MT CO_2e

Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles

Identify all vehicles under operational control of the agency by vehicle type (passenger car, light-duty truck, heavy-duty truck, motorcycle), fuel type (gasoline, diesel), and emission control technology (low emission vehicles, moderate control technologies, etc.). A table of control technologies can be found in Appendix D as well as descriptions of the EPA's tiered technology categories in the Definitions section.[16]

Step 2: Determine mileage by vehicle type

For each vehicle type referenced in Appendix D determine distance traveled for the reporting period.

Step 3: Determine the appropriate emission factors for fuel and vehicle type

See Appendix D for emissions factors by vehicle type, technology, and weighted assumptions by year. The weighted assumptions provide the estimated emissions factor by type of vehicle and year. Additional tables present the percentage of vehicles by type in each year that was designed with the EPA's tiered designations if the vehicle population by type of technology is not known but date of purchase is known. Agencies should establish what information is available on their fleet and use the best estimates of its composition. More information on these tiers is available in the EPA Climate Leader's Mobile Combustion Sources Guidance.

Step 4: Calculate CH_4 and N_2O emissions by vehicle type and sum

For each category of vehicle type, technology, and fuel Equation A-6 should be used for CH_4 and N_2O emissions.

Equation A-6: Total Mobile Combustion of CH_4 and N_2O (Fossil Fuels)

CH_4 Emissions (kg CH_4) = total miles ● CH_4 emissions kg/mile **N_2O Emissions (kg N_2O)=** total miles ● N_2O emissions kg/mile

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[16] While it requires more detailed records, this method is required in order to account for reductions obtained from certain emission savings strategies (e.g., creating a "cleaner" mix of fleet vehicles).

Step 5: Determine the total annual MT CO$_2$e

To determine the total CO$_2$e emissions, multiply by the appropriate GWP for each gas found in Appendix D.

Equation A-7: Mobile Combustion of CH$_4$ and N$_2$O (Fossil Fuels) in MT CO$_2$e

CH$_4$ Emissions (MT CO$_2$e) =
kg CH$_4$ ● GWP CH$_4$ ● 1 MT/1,000 kg

N$_2$O Emissions (MT CO$_2$e) =
kg N$_2$O ● GWP N$_2$O ● 1 MT/1,000 kg

Then, sum emissions of all three gases to determine your total GHG emissions from mobile combustion.

Example A-3: Mobile Combustion (Fossil Fuels) – Detailed Methodology

CO_2 Step 1: Determine annual fuel consumed
A truck owned by the agency consumed 2,350 gallons of diesel fuel.

CO_2 Step.2: Select emission factors
The CO_2 emissions factor for petroleum diesel is 10.15 kg CO_2/gal.

CO_2 Step 3: Determine the total annual GHG emissions in kg of CO_2 equivalent

Equation A-5: CO_2 emissions
Diesel CO_2 emissions = Vehicle fuel consumption ● CO_2 emissions/gal ● 1 MT/1,000 kg
$\qquad$ = 2,350 gal ● 10.15 kg CO_2/gal ● 1 MT/1,000 kg
$\qquad$ = 24.699 MT CO_2

CH_4 and N_2O Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles
The 1993 truck's average mileage is 15 mpg. It uses moderate emissions control technology.

CH_4 and N_2O Step 2: Determine mileage by vehicle type
The truck uses 2,340 gallons of diesel fuel and achieved average mileage of 15 mpg, driving a total of 35,250 miles.

CH_4 and N_2O Step 3: Determine the appropriate emission factors for fuel and vehicle type
The CH_4 and N_2O emission factors for a diesel light truck with moderate emission control technology are 1.4×10^{-6} kg/mile and 9.0×10^{-7} kg/mile respectfully.

CH_4 and N_2O Step 4: Calculate CH_4 and N_2O emissions by vehicle type and sum

Equation A-6: CH_4 and N_2O emissions
CH_4 Emissions = total miles ● CH_4 emissions/mile ● 1 MT/1,000 kg
$\qquad$ = 35,250 miles ● 0.9×10^{-6} kg/mile ● 1 MT/1,000 kg
$\qquad$ = 3.173×10^{-5} MT CH_4

N_2O Emissions = total miles ● N_2O emissions/mile ● 1 MT/1,000 kg
$\qquad$ = 35,250 miles ● 1.4×10^{-6} kg/mile ● 1 MT/1,000 kg
$\qquad$ = 4.935×10^{-5} MT N_2O

CH_4 and N_2O Step 5: Determine the total annual MT CO_2e:

Equation A-7: CO_2 equivalent emissions
Diesel CO_2 emissions = 24.699 MT CO_2
Diesel CH_4 emissions = MT CH_4 ● GWP CH_4
$\qquad$ = 3.173×10^{-5} MT CH_4 ● 21
$\qquad$ = 6.663×10^{-4} MT CO_2e
Diesel N_2O emissions = MT N_2O ● GWP N_2O
$\qquad$ = 4.935×10^{-5} MT ● 310
$\qquad$ = 1.53×10^{-2} MT CO_2e
Total CO_2e emissions = 24.699 + 6.663×10^{-4} + 1.53×10^{-2}
$\qquad$ **= 24.715 MT CO_2e**

Non-Highway Vehicles

A list of default emissions factors for non-highway vehicles are included in Appendix D to assist in calculating emissions for aircraft, boats and ships, agriculture equipment, and various other vehicle and fuel types. Estimating emissions from these vehicles also requires data on the quantity of fuel consumed by fuel types. The same general calculation methodology described for highway vehicles applies to non-highway vehicles. As for those vehicles recorded by hours traveled, the agency should use known vehicle efficiency data to come to resulting total fuel usage or mileage. Emissions for non-highway vehicles are available in EPA's Climate Leader's guidance, Table A-6:
http://www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

A.3 Mobile Combustion: Biofuel

Description

GHG emissions from biofuel combustion usually arise from vehicles such as cars, trucks, airplanes and water vessels. Agencies should include CH_4 and N_2O emissions as scope 1, whereas CO_2 emissions should be attributed separately. The CH_4 and N_2O calculations do not differ from section A.2

A.3.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

Use FAST for fuel consumption totals.

Table A-4: Mobile Combustion: Biofuel Minimum Required Data Sources

Data Element	Preferred Source
Annual Fuel Consumption data by type (gal)	• FAST database
CH_4 and N_2O: Annual fuel consumption data by type (gal)[17]	• FAST database
Biobased fraction of fuel	• Calculated percentage of annual fuel consumption
Emission Factor	• CO_2: See Appendix D by fuel type, • CH_4 and N_2O: See Appendix D by fuel type

Calculation Steps for CO_2 Emissions[18]

To calculate scope 1 CO_2 emissions from mobile combustion of biofuels:

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[17] This applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For these vehicles, estimation of CH_4 and N_2O emissions is based on fuel consumption rather than distance traveled.

[18] Primary Reference: EPA Climate Leaders Technical Guidance, Direct Emissions from Mobile Combustion Sources, May 2008.

1. Determine the total amount of fuel consumed by type

2. Select the appropriate CO_2 emissions factor for fuel type

3. Determine biofuel and fossil fuel portion of the blend and calculate CO_2 emissions

4. Calculate total emissions in MT CO_2e

Step 1: Determine the total amount of fuel consumed by type

Biofuel blends are indicated in terms of the percentage fraction of biofuel blended with a fossil fuel. For example, B20 contains 20 percent biodiesel and 80 percent petroleum diesel. Likewise with ethanol blends, E85 contains 85 percent ethanol and 15 percent gasoline. Under current reporting rules, E10 is considered gasoline, and B5/B10 is considered straight diesel. B20 and larger are considered biodiesel. When using FAST, the agency may have to convert from gasoline equivalent gallons; a conversion table is in Appendix D.

Step 2: Select the appropriate CO_2 emissions factor for fuel type

The fractional components of the biofuels have different carbon contents, requiring the CO_2 emissions for each fraction to be calculated separately. See Appendix D for fuel emission factors.

Step 3: Determine biofuel and fossil fuel portion of the blend and calculate CO_2 emissions

Equation A-8: Biofuel CO_2 Emissions

Biofuel CO_2 emissions =
Total fraction of biofuel in fuel consumed (gal) ● CO_2 emissions/gal

Fossil fuel CO_2 emissions =
Total fraction of fossil fuel in fuel consumed (gal) ● CO_2 emissions/gal

Step 4: Calculate total emissions in MT CO_2e

Convert the CO_2 emissions into metric tons. Report the CO_2 from the fossil fuel fraction as scope 1, report CO_2 from the biofuel separately.

Calculation Steps for CH4 and N2O Emissions

Use the method described in section A.2 to calculate the CH_4 and N_2O emissions in MT CO_2e. Report CH_4 and N_2O emissions for both fossil and biofuel components as scope 1.

A.3.2 Detailed Methodology (User Calculated)

Data Sources

Data sources for calculating CO_2 emissions are the same as the minimum required method and sources for calculating CH_4 and N_2O are the same as Section A.2

Calculation Steps for CO2, CH4 and N2O Emissions

The detailed methodology for CO_2 is the same as the minimum required. The CH_4 and N_2O detailed methodology is described in Section A.2 and does not require breaking out the portion of biobased fuel.

Example A-4: Biofuel Combustion

Step 1: Determine the total amount of fuel consumed by type
A light truck owned by an agency consumed 2,500 gallons of B20. This equates to 500 gallons of biodiesel and 2,000 gallons of regular petrodiesel.

Step 2: Select the appropriate CO_2 emission factors for fuel type
The biodiesel emissions factor is 9.46 kg CO_2/gal and the petrodiesel emission factor is 10.15 kg CO_2/gal.

Step 3: Determine biodiesel and petrodiesel portion of the blend and calculate CO_2 emissions

Equation A-8: Biofuel CO_2 Emissions
Biodiesel CO_2 emissions = Total fraction of biodiesel in fuel consumed (gal) ● CO_2 emissions/gal
$$= 500 \text{ gal} ● 9.46 \text{ kg } CO_2/\text{gal}$$
$$= 4{,}730 \text{ kg } CO_2$$
Petrodiesel CO_2 emissions (Scope 1) = Total fraction of petrodiesel in fuel consumed (gal) ● CO_2 emissions/gal
$$= 2{,}000 \text{ gal} ● 10.15 \text{ kg } CO_2/\text{gal}$$
$$= 20{,}300 \text{ kg } CO_2$$

Step 4: Calculate total emissions in MT CO_2e
The scope 1 CO_2 emissions are added to the total amount of CH_4 and N_2O emissions calculated below (see Example A-2 for more explanation). The truck has an average efficiency of 21 miles per gallon and used 2,500 gallons. It traveled approximately 52,500 miles.

Equation A-6: CH_4 and N_2O emissions (All scope 1)
B20 CH_4 Emissions = total miles ● kg CH_4 emissions/mile ● 1 MT/1,000 kg
$$= 52{,}500 \text{ miles} ● 0.9 \times 10^{-6} \text{ kg } CH_4/\text{mile} ● 1 \text{ MT}/1{,}000 \text{ kg}$$
$$= 4.725 \times 10^{-5} \text{ MT } CH_4$$

B20 N_2O Emissions = total miles ● kg N_2O emissions/mile ● 1 MT/1,000 kg
$$= 52{,}200 \text{ miles} ● 1.4 \times 10^{-6} \text{ kg } N_2O/\text{mile} ● 1 \text{ MT}/1{,}000 \text{ kg}$$
$$= 7.35 \times 10^{-5} \text{ MT } N_2O$$

Equation A-7: CO_2 equivalent emissions
B20 CO_2 emissions (Scope 1) = 20,300 kg CO_2 ● 1 MT/1,000 kg
$$= 20.3 \text{ MT } CO_2$$
B20 CH_4 emissions (Scope 1) = MT CH_4 ● GWP CH_4
$$= 4.725 \times 10^{-5} \text{ MT } CH_4 ● 21$$
$$= 9.923 \times 10^{-4} \text{ MT } CO_2e$$
B20 N_2O emissions (Scope 1) = MT N_2O ● GWP N_2O
$$= 7.35 \times 10^{-5} \text{ MT} ● 310$$
$$= 2.278 \times 10^{-2} \text{ MT } CO_2e$$
Total B20 CO_2e emissions (Scope 1) = $20.3 + 9.923 \times 10^{-4} + 2.278 \times 10^{-2}$
$$\mathbf{= 20.324 \text{ MT } CO_2e}$$
Total B20 Biogenic CO_2e emissions (Not scope 1) = 4,730 kg CO_2 ● 1 MT/1,000 kg
$$\mathbf{= 4.73 \text{ MT } CO_2}$$

A.4 Biomass Combustion

Description

Biomass combustion emissions usually come from boilers, backup generators, and incinerators. Biomass fuels include, in short, wood (chips, pellets, etc.), using landfill gas to reduce natural gas consumption, and biodiesel in generators.

A.4.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

These calculations mirror the stationary combustion method (see Section A.1 and are only summarized here. Biomass CO_2 must be calculated separately, but its CH_4 and N_2O emissions are scope 1.

Table A-5: Biomass Combustion Minimum Required Data Sources

Data Element	Preferred Source
Wood and Wood Waste: Total amount	• Agency records
Emission Factor	• See Appendix D by fuel type

Calculation Steps

1. Determine amount of fuel consumed annually

2. Determine the appropriate CO_2 emission factors for each fuel

3. Determine the appropriate CH_4 and N_2O emission factors for each fuel

4. Calculate each fuel's CO_2 emissions (Equation A-1)

5. Calculate each fuel's CH_4 and N_2O emissions (Equation A-2, A-3)

6. Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions (Equation A-4)

Example A-5: Biomass Combustion

Step 1: Determine amount of fuel consumed annually
A facility burned 134 tons of wood waste in a biomass boiler to reduce its natural gas use. The Heat Content of wood waste is 15.38 MMBtu/ton. This results in 2060.82 MMBtu.

Step 2: Determine the appropriate CO_2 emission factors for each fuel
The CO_2 emissions factor for this example is 93.87 kg CO_2/MMBtu.

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel
The natural gas emissions factors for CH_4 and N_2O are 0.316 and 0.0042 kg /MMBtu

Step 4: Calculate each fuel's CO_2 emissions

Equation A-1: Biomass Combustion CO_2
CO_2 (MT) = Fuel consumed (MMBtu) ● emission factor (kg CO_2/ MMBtu) ● 1 MT/1,000 kg
      = 2060.92 MMBtu ● 93.87 kg CO_2/ MMBtu ● 1 MT/1,000 kg
      = 193.459 MT CO_2

Step 5: Calculate each fuel's CH_4 and N_2O emissions

Equation A-2: Stationary Combustion CH_4
CH_4 (MT) = Fuel consumed (MMBtu) ● emission factor (kg CH_4/ MMBtu) ● 1 MT/1,000 kg
      = 2060.92 MMBtu ● 0.316 kg CH_4/ MMBtu ● 1 MT/1,000 kg
      = 0.651 MT CH_4

Equation A-3: Stationary Combustion N_2O
N_2O (MT) = Fuel consumed (MMBtu) ● emission factor (kg N_2O / MMBtu) ● 1 MT/1,000 kg
      = 2060.92 MMBtu ● .0042 kg N_2O / MMBtu ● 1 MT/1,000 kg
      = .00866 MT N_2O

Step 6: Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions

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Equation A-4: Stationary Combustion MT CO_2e Emissions
Total CO_2e Emissions (Scope 1) = (MT CH_4 ● GWP CH_4) + (MT N_2O ● GWP N_2O)
      = (0.651 MT CH_4 ● 21) + (.0087 MT N_2O ● 310)
      = 13.671 + 2.683
      = 16.354 MT CO_2e
Total Biogenic CO_2 Emissions (Not Scope 1) = 193.459 MT CO_2

A.5 Fugitive Emissions: Refrigerants and F-gases

Description

For purposes of inventory development, fugitive process emissions are non-combustion emissions of F-gases resulting from process, equipment design, or operational practices that do not pass through a stack, chimney, or other functionally-equivalent opening (point source), and which are not captured or treated by an emissions control system.

This section discusses alternative approaches for calculating scope 1 fugitive process emissions of greenhouse gases. For most if not all agencies the only fugitive process emissions of significance are fluorinated greenhouse gases (F-gases - HFCs, PFCs and SF_6). Therefore only fluorinated greenhouse gas fugitive process emissions are required to be inventoried. For purposes of inventory development, fugitive process emissions are non-combustion emissions of F-gases resulting from process, equipment design, or operational practices that do not pass through a stack, chimney, or other functionally-equivalent opening (point source), and which are not captured or treated by an emissions control system.

Emissions of fluorinated GHGs can occur during the manufacture, installation, use, service, and disposal of heating, ventilation and air conditioning (HVAC) and refrigeration equipment; mobile source air conditioning equipment; and electrical equipment in which sulfur hexafluoride or PFCs are used as electrical insulators. (Such electrical equipment includes gas-insulated circuit breakers, switch gear, and substations, gas-insulated lines, and some transformers).

For purposes of this document, it is assumed that all agency emissions of F-gases are "fugitive." However, if an agency has F-gas emissions that are "non-fugitive" (i.e., pass through a stack, chimney, or other opening), an agency must calculate these emissions and include them in their inventory. Refer to the end of this appendix for a list of possible guidance documents. CEQ acknowledges that agencies may not be able to collect fugitive emission data for the FY 2008 baseline. Agencies are required to do so to the best of their ability.

General Data Sources

In general, the information required to estimate F-gas emissions from HVAC, refrigeration, and electrical equipment consists of data on F-gas consumption and on the net growth (or decline) of the total charge (nameplate capacity) of the equipment during the year. The net growth or decline of the total charge can be tracked simply by tracking the total quantities of equipment newly installed or retired, but the total charge is useful for its own sake in applying the screening analysis (discussed further below) or calculating emission rates (e.g., kg HFC emitted per kg HFC charge).

The ease and ability of obtaining the underlying activity data needed to calculate fugitive GHG emissions may be influenced by the size, mission and maintenance capabilities of an agency. Larger organizations may operate agency-specific logistics and supply management systems at the facility level that provide for uniform stock control through standardized procedures covering the requisition, purchase, receipt, storage, issue, shipment, disposition, and identification of equipment and supply materials, and may provide in-house maintenance of equipment. If these systems are not centrally accessible at the agency headquarters level, formal data calls may be needed to obtain the necessary data from individual agency locations and rolled up to provide an agency-wide inventory.

Smaller organizations may not have the same logistics, data management, and equipment maintenance needs, and/or may contract out such services. In some cases it may not be cost effective or feasible to get complete information on emissions from material supplied via facility support/service contractors; therefore best judgment estimates may be required in these

circumstances to fill data gaps. Agencies may wish to consider modifying facility support/service contracts to require contractors to provide this data for future inventories.

Specific data requirements will depend on the methodology applied, as described below.

Minimum Required and Detailed Methodologies[19]

Depending on the quality of available underlying data there are four general methodologies for calculating fugitive F-gas emissions:

1. Minimum Required: Federal supply system transaction screening approach

2. Detailed Methodology: Material balance approach,

3. Alternative Detailed Methodology: Simplified material balance approach, and

4. Alternative Detailed Methodology: Screening approach.

The material balance approach is recommended, as it is the most accurate. However, any one of four approaches may be used by agencies to calculate F-gas fugitive emissions. Methodologies 2 through 4 are detailed in guidance such as EPA's Climate Leaders Program. The minimum required method is a simplified screening method based upon the use of Federal supply system requisition and/or local purchase data.

The material balance methodologies (2 and 3) discussed are applicable for calculating emissions of all F-gases whether they are being used as refrigerants, solvents, electrical insulator, dielectric/arc quenching compounds, or other applications. Many federal agencies may not already collect the activity data necessary to use the material balance methodologies for calculation and reporting of fugitive emissions. Because it may not be cost effective or efficient, screening methods (1 and 4) have also been provided for this emissions category. If use of the screening method results in an emissions estimate that exceeds five percent of total GHG emissions for an agency/facility, then consideration should be given to collecting the underlying activity data necessary to conduct more accurate emissions calculations.

Agencies using methodologies 2 through 4 may also want to consider setting a lower threshold for the minimum charge size of equipment that will be inventoried. Conducting equipment inventories of many small sealed refrigerant systems containing only small quantities of HFCs in each system may not an be efficient use of resources given the minor emissions from these systems. For example, an agency might consider excluding equipment that have installed charge sizes of less than 50 pounds such as household refrigeration/small appliances, stand-alone commercial-type refrigeration applications, smaller residential and commercial-type AC and heat-pumps, and small sealed electrical/electronic devices containing SF_6.

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[19] Primary Reference: US EPA Climate Leaders Technical Guidance, Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, May 2008; US EPA TSD for Emissions from Production of Fluorinated GHGs: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

A.5.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

The Federal Supply System Transaction Screening Approach is essentially a much simplified version of the Material Balance Approach that has been used by several Federal Agencies in conjunction with the development of inventories of ODS. Central to this methodology is the assumption that the quantity of F-gas an agency purchases or issues to maintain equipment minus the quantity returned can be used as a reasonable surrogate for actual emissions. This assumption is reasonable when the total charge of a particular F-GHG in the installed equipment is fairly constant from year to year. However, if the total charge is declining (because more equipment containing the F-GHG is being retired than is being installed) - this assumption could lead to an underestimate of F-gas emissions.[20] Thus, if the agency knows that their total charge is declining significantly, they should consider using one of the other methodologies provided.

Data Sources

Agencies will need to obtain purchase/supply requisition data on each F-gas from local or centralized sources (see Table A-6).

It is often that case that chemical compounds are listed by chemical name or trade name. This can lead to confusion when a single compound is referred to by multiple names. However, the American Chemical Society assigns each compound a Chemical Abstract Service (CAS) number. The CAS number is a unique numeric identifier for chemical compounds that should be used when searching a chemical inventory database for industrial chemicals.

Table A-6: Fugitive Emissions Minimum Required Data Sources - The Federal Supply System Transaction Screening Approach

Data Element	Preferred Source	Alternate Source
Amount and type of each F-gas issued from storage.	• GSA • Defense Logistics Agency • Agency logistics/supply organizations • Chemical inventory tracking system	• Local hazardous material management/distribution centers • Purchase records • Maintenance records
Amount recovered from equipment and the amount returned to the supply system.	• See Above	• See Above

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[20] This is extremely important. If little or no new equipment is being installed, but significant amounts of old equipment are being retired, emissions can occur without resulting in demand for new gas. Specifically, emissions can occur between the final servicing of equipment and its retirement or during its retirement. These emissions could account for most or even all of the equipment charge. In cases where at least some of the equipment charge is recovered and recycled, that charge can be used to service existing equipment (whose charge has leaked previously), offsetting demand for new gas that would have occurred if the gas from the retiring equipment were not available. The standard mass-balance approach accounts for all of these possibilities, but this "transaction screening approach" does not.

Calculation Steps

To calculate scope 1 emissions from fugitive emissions:

1. Collect transaction data

2. Find the difference in amount recovered and returned

3. Estimate annual emissions

4. Convert to MT CO_2e and total emissions

Step 1: Collect transaction data

Identify the CAS number(s) of the F-gas in question. Obtain supply system transactional data to determine amount and type of each F-gas issued from storage.

Step 2: Find the difference in amount recovered and returned

Subtract from amount issued the amount recovered from equipment and the amount returned to the supply system.

Step 3: Estimate annual emissions

Estimate annual emissions of each type of F-gas, using Equation A-9.

Equation A-9: Annual F-gas Emissions

Annual Emissions (MT F-gas) =
$(I - R) \div 1{,}000$ (kg/metric ton)

Where:
I = Amount of F-gas issued from supply system (kg)
R = Amount of F-gas returned to supply system from equipment (includes both the amount recovered from equipment during maintenance and the unused amount originally issued from supply) (kg)

Step 4: Convert to MT CO_2e and total emissions

Convert to units of CO_2e using Equation A-10 and sum total F-gas emissions,

In all cases, the total quantity of each F-gas requisitioned/purchased is then multiplied by the GWP of each F-gas to calculate CO_2e emissions. In some cases, however, it may be necessary to first convert gas that is reported in a volume-based format to a traditional mass-based format in order to report emissions. Note that in some cases it may not be cost effective or feasible to get complete information on "purchase" of material from other local sources such as material supplied via facility support/service contractors; therefore best judgment estimates may be required.

In the examples below, the refrigerant HFC-23 (CAS number 75-46-7) is listed under two names: trifluoromethane and fluoroform, illustrating the importance of using CAS numbers when querying supply systems. They provide steps for applying the supply system transaction screening approach when the supply system provides information in both a mass-based and a volume-based format.

Example A-6: Federal Supply System Transaction Screening when Supply data is available in Mass-Based Format

Step 1: Collect transaction data

Supply System Transaction Screening Sample Data

Amount of HFC-23 issued from supply system	100 kg
Amount of HFC-23 returned to supply system from equipment	25 kg

Step 2: Find the difference in amount recovered and returned
Step 3: Estimate annual emissions

Equation A-9:
Annual Emissions (MT HFC-23) $= (I - R) \div 1{,}000$ (kg/metric ton)
$$= (100 \text{ kg} - 25 \text{ kg}) \div 1{,}000 \text{ kg/MT}$$
$$= 0.075 \text{ MT HFC-23}$$

Where:
I = Amount of F-gas issued from supply system (kg)
R = Amount of F-gas returned to supply system from equipment (includes both the amount recovered from equipment during maintenance and the unused amount originally issued from supply) (kg)

Step 4: Convert to MTCO$_2$e and total emissions

Equation A-11:
CO$_2$e (MT F-gas) $=$ Annual Emissions (MT) • F-gas GWP
$$= 0.075 \text{ MT} • 11{,}700$$
$$= 877.5 \text{ MT CO}_2\text{e}$$

Example A-7: Federal Supply System Transaction Screening when Supply data is available in Volume-Based Format

Step 1: Collect transaction data

Example calculation: The chemical inventory report shows that there are three canisters of HFC-23 that have been issued and returned through the supply system over the past year. The amounts of gas are listed:

Canister number	Gas quantity	CAS Number	Chemical Name	Transaction
3778546	100 kg	75-46-7	Trifluoromethane	Issue
3645585	10 cu ft	75-46-7	Fluoroform	Issue
3654486	25 kg	75-46-7	Trifluoromethane	Return

Step 2: Find the difference in amount recovered and returned

In order to use the information to calculate emissions, the volumetric data must first be converted to an equivalent mass by obtaining the density of the gas. This can be accomplished by referring to available Material Safety Data Sheet (MSDS) information for HFC-23. The gas HFC-23 has a density of 2.99 kg/cu m. In the interest of accuracy and verifiability, it is important to note in the GHG inventory which gas density value was used for the calculation, as well as the source of the value.

First, convert the volume of HFC consumed to an equivalent mass-based format:

To calculate the total mass of the HFC-23 emitted, use the following calculation, recognized conversion factors, and the density information from the MSDS:

Total mass of HFC-23 = volume of gas ● cubic meters/cubic feet ● density of gas
= 10 cu ft ● 0.0283 cu m/cu ft ● 2.99 kg/cu m
= 8.46 kg

Step 3: Estimate annual emissions

Equation A-9:
Annual Emissions (MT HFC-23) = $(I - R) \div 1{,}000$ (kg/metric ton)
$= (100 \text{ kg} - 8.46 \text{ kg}) \div 1{,}000 \text{ kg/MT}$
$= 0.0835$ MT HFC-23

Where:
I = Amount of F-gas issued from supply system (kg)
R = Amount of F-gas returned to supply system from equipment (includes both the amount recovered from equipment during maintenance and the unused amount originally issued from supply) (kg)

Step 4: Convert to MTCO$_2$e and total emissions

Equation A-11:
CO$_2$e (MT F-gas) = Annual Emissions (MT) ● F-gas GWP
= 0.0835 MT ● 11,700
= 976.96 MT CO$_2$e

A.5.2 Detailed Methodologies (User Calculated)

There are three detailed methodologies that the user can choose to use to calculate fugitive emissions.

1. Alternative Detailed Methodology: The Material Balance Approach,

2. Alternative Detailed Methodology: Simplified Material Balance Approach, and

3. Alternative Detailed Methodology: Screening Approach.

Alternative Methodology 1: The Material Balance Approach

A material balance approach is the most accurate method for determining fugitive F-gas emissions.

Data Sources

This methodology requires detailed information on the type of each F-gas used by your organization and each piece of F-gas-containing equipment operated at the facility level.

Table A-7: Fugitive Emissions Detailed Data Sources - The Material Balance Approach

Data Element	Preferred Source
F-gas in inventory (storage not equipment) at the beginning of reporting period	• Purchase records • Maintenance records • Chemical inventory tracking system
F-gas purchased during the reporting period	• Same as above
Total capacity of F-gas in equipment at the beginning of the reporting period	• Same as above
F-gas in inventory (storage not equipment) at the end of reporting period	• Same as above
F-gas sold or otherwise disposed during reporting period	• Same as above
Total capacity of F-gas in equipment at the end of the reporting period	• Same as above

Calculation Steps

To calculate scope 1 emissions from fugitive emissions:

1. Determine base inventory

2. Calculate changes to the base inventory

3. Calculate annual emissions

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4. Convert to MT CO_2e

5. Determine sum emissions for each facility

Step 1: Determine base inventory

Determine the base inventory for each F-gas in use at each facility by determining the quantity of F-gas in storage at the beginning of the year (does not include F-gas contained within equipment) and the quantity in storage at the end of the year.

Step 2: Calculate changes to the base inventory

For each F-gas determine purchases[21] and other acquisitions, sales[22] and other disbursements and net change to the total equipment volume for a given F-gas during the year.[23]

Step 3: Calculate annual emissions

For each F-gas or F-gas blend, use Equation A-10.

Equation A-10: Annual F-gas Emissions

Annual Emissions (MT F-gas) =
$(I_B - I_E + P - S + C_B - C_E) \div 1{,}000$ (kg/MT))

Where:
I_B = Initial quantity of F-gas in storage for the inventory year (kg)
I_E = End quantity of F-gas in storage for the inventory year (kg)
P = Sum of all the F-gas purchased (kg)
S = Sum of all the F-gas sold (kg)
C_B = Total capacity of F-gas in equipment at the beginning of the inventory year (kg)
C_E = Total capacity of F-gas in equipment at the end of the inventory year (kg)

Step 4: Convert to MT CO_2e

Use Equation A-11 to convert GWP for each gas can be found in Appendix D.

Equation A-11: Conversion to MT CO_2e

CO_2e (MT F-gas) =
Annual Emissions (MT) • F-gas GWP

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[21] Purchases are the sum of all the individual F-gas (e.g., HFC, PFC, SF_6) acquired during the year either in storage containers or in equipment. Includes : purchased from producers or distributors, provided by manufactures or inside equipment, added to equipment by contractors or other service personnel (but not if that refrigerant is from your inventory), and returned after off-site recycling or reclamation.

[22] Sales are the sum of all the refrigerants sold or otherwise disbursed during the year either in storage containers or in equipment. Includes F-gases in containers or left in equipment that is sold, returned to suppliers, and sent off-site for recycling, reclamation, or destruction.

[23] The net increase in total full charge of equipment refers to the full and proper charge of the equipment rather than to the actual charge, which may reflect leakage.

Step 5: Determine sum emissions for each facility

Sum all MT CO_2e emissions from each F-gas type.

Example A-8: Material Balance

Step 1: Determine base inventory

Material Balance Sample Data

Beginning of year	620 kg
End of year	600 kg
Purchases of HFC-23	200 kg
HFC-23 sold	0.0 kg
Total nameplate capacity of HFC-23 equipment retired during the inventory year	20 kg
Total nameplate capacity of new HFC-23 in equipment installed during the inventory year	10 kg

Step 2: Calculate changes to the base inventory

Step 3: Calculate annual emissions

Equation A-10:
Annual Emissions (MT HFC) $= I_B - I_E + P - S + C_B - C_E) \div 1{,}000$ (kg/MT))
$$= (620 \text{ kg} - 600 \text{ kg} + 200 \text{ kg} + 0.0 \text{ kg} + 20 \text{ kg} - 10 \text{ kg}) \div 1{,}000 \text{ kg/MT}$$
$$= 0.23 \text{ MT HFC-23}$$
Where:
I_B = Initial quantity of F-gas in storage for the inventory year (kg)
I_E = End quantity of F-gas in storage for the inventory year (kg)
P = Sum of all the F-gas purchased (kg)
S = Sum of all the F-gas sold (kg)
C_B = Total capacity of F-gas in equipment at the beginning of the inventory year (kg)
C_E = Total capacity of F-gas in equipment at the end of the inventory year (kg)

Step 4: Convert to MT CO_2e and total emissions

Equation A-11:
CO_2e (MT F-gas) $=$ Annual Emissions (MT) $\bullet$ F-gas GWP
$$= 0.23 \text{ MT} \bullet 11{,}700$$
$$= 2{,}691 \text{ MT}$$

Alternative Methodology 2: The Simplified Material Balance Approach

The Simplified Material Balance Method is a Material Balance Method that may be more suitable for those activities that have their equipment serviced by outside entities. For this method, agencies will need the following data by F-gas type:

Table A-8: Fugitive Emissions Detailed Data Sources – Simplified Material Balance Approach

Data Element	Preferred Source
F-gas used to charge new equipment (omitted if the equipment has been pre-charged by the manufacturer)	• Purchase records • Maintenance records • Chemical inventory tracking system
Total full capacity of the new equipment (omitted if the equipment has been pre-charged by the manufacturer)	• Same as above
Quantity of F-gas used to service equipment.	• Same as above
Total full capacity of retiring equipment	• Same as above
F-gas recovered from retiring equipment	• Same as above

Calculation Steps

To calculate scope 1 emissions from fugitive emissions:

1. Determine base inventory

2. Calculate annual emissions

3. Convert to MT CO_2e and total emissions

Step 1: Determine base inventory

Determine the types and quantities of F-gas used at each facility by determining the quantity of F-gas used to charge new equipment and service existing equipment, and recovered from retiring equipment. Also determine total full capacity of new and retiring equipment.

Step 2: Calculate annual emissions

For each type of F-gas determine any emissions from installation, operation or disposal of equipment. If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Using Equation A-12, add emissions from each piece of equipment to get the total emissions.

Equation A-12: Annual F-gas Emissions

Annual Emissions (MT F-gas) =
$(P_N - C_N + P_S + C_D - R_D) \div 1{,}000$ (kg/metric tons)

Where: *
P_N = purchases of F-gas used to charge new equipment (kg).
C_N = total full charge of the new equipment (kg).
P_S = quantity of F-gas used to service equipment (kg).
C_D = total full charge of retiring equipment (kg).
R_D = F-gas recovered from retiring equipment (kg).

* If no new purchases or retired equipment, variables can be omitted

Step 3: Convert to MT CO$_2$e and total emissions

Use Equation A-11 to convert to emissions associated with each F-gas to MT CO$_2$e and sum total F-gas emissions at each facility.

Example A-9: Simplified Material Balance

Step 1: Determine base inventory

Simplified Material Balance Sample Data

Purchases of HFC-23	700 kg
Total full charge of the new equipment	400 kg
Quantity of HFC-23 used to service equipment	200 kg
Total full charge of retiring equipment	360 kg
HFC-23 recovered from retiring equipment	100 kg

Step 2: Calculate annual emissions

Equation A-12:
Annual Emissions (MT HFC-23) = $(P_N - C_N + P_S + C_D - R_D) \div 1{,}000$ (kg/metric tons)
$\qquad = (700 \text{ kg} - 400 \text{ kg} + 200 \text{ kg} + 360 \text{ kg} - 100 \text{ kg}) \div 1{,}000 \text{ kg/MT}$
$\qquad = 0.76 \text{ MT HFC-23}$

Where:
P_N = purchases of F-gas used to charge new equipment (kg).
C_N = total full charge of the new equipment (kg).
P_S = quantity of F-gas used to service equipment (kg).
C_D = total full charge of retiring equipment (kg).
R_D = F-gas recovered from retiring equipment (kg).

Step 3: Convert to MT CO$_2$e and total emissions

Equation A-11:
CO$_2$e (MT F-gas) = Annual Emissions (MT) • F-gas GWP
$\qquad = 0.76 \text{ MT} \bullet 11{,}700$
$\qquad = 8{,}892 \text{ MT CO}_2\text{e}$

Alternative Methodology 3: The Screening Approach

An agency multiplies the amount of F-gas in the equipment by an emission factor for that specific type of equipment or emission event. The disadvantage to using this approach is that factors used to estimate emissions are very general in nature and hence highly uncertain.

Data Sources

To use this screening method an agency must have an inventory of equipment by quantity, equipment category, F-gas type, and total charge capacity.

Table A-9: Fugitive Emissions Detailed Data Sources - Screening Approach

Data Element	Preferred Source
Inventory of equipment by number, equipment category, F-gas type, and total charge capacity	• Purchase records • Maintenance records • Chemical inventory tracking system
Amount of F-gas in the equipment	• Same as above
Emission Factor	• See Appendix D

Calculation Steps

To calculate scope 1 emissions from fugitive emissions:

1. Determine base inventory

2. Calculate annual emissions

3. Convert to MT CO_2e and total emissions

Step 1: Determine base inventory

Determine the quantity and types of equipment, by equipment category; the types of F-gas used; and the F-gas charge capacity of each piece of equipment.

Step 2: Calculate annual emissions

For each type of F-gas, determine any emissions from installation, operation or disposal of equipment. Equation A-13 combines these three sources, where the emissions from installation equal the amount of refrigerant charged into new equipment multiplied by the assembly losses ($C_N \bullet k$), emissions from operation equal the charge capacity multiplied by the annual leak rate and time used ($C \bullet x \bullet T$), and disposal equals the charge capacity being disposed of multiplied by percent capacity remaining and percent refrigerant removed ($C_D \bullet y \bullet (1 - z)$). If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Use default emission factors provided in Table A-10 by equipment type. Estimate annual emissions of each F-gas type, using Equation A-13.

Equation A-13: Annual F-gas Emissions

Annual Emissions (MT F-gas) =
$[(C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z))] \div 1{,}000$ (kg/metric ton)

Where:
C_N = quantity of F-gas charged into the new equipment (kg).*
C = total full charge (capacity) of the equipment (kg).
T = time equipment was in use (e.g., 0.5 if used only during half the year and then disposed) (yrs).
C_D = total full charge (capacity) of equipment being disposed (kg).[24]
k = installation emission factor (%).
x = operating emission factor (%).
y = refrigerant remaining at disposal.
z = recovery efficiency.

* If no equipment added, variables can be omitted.

**Table A-10: Default F-Gas Emission Factors for Refrigeration/
Air Conditioning Equipment**

Type of Equipment	Capacity (kg)	Installation Emission Factor k (% of capacity)	Operating Emission Factor x (% of capacity/yr)	Refrigerant Remaining at Disposal y (% of capacity)	Recovery Efficiency z (% of remaining)
Domestic Refrigeration	0.05 – 0.5	1%	0.50%	80%	70%
Stand-alone Commercial Applications	0.2-6	3%	15%	80%	70%
Medium & Large Commercial Refrigeration	50 – 2,000	3%	35%	100%	70%
Transport Refrigeration	3-8	1%	50%	50%	70%
Industrial Refrigeration including Food Processing and Cold Storage	10 - 10,000	3%	25%	100%	90%
Chillers	10 - 2,000	1%	15%	100%	95%
Residential and Commercial A/C including Heat Pumps	0.5 - 100	1%	10%	80%	80%
Mobile Air Conditioning	0.5 - 1.5	0.50%	20%	50%	50%

Source: Table 16.3 in TCR General Reporting Protocol, Version 1.1, May 2008, and Table 2 in EPA Climate Leaders Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment.

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[24] Omit if no equipment was disposed of during the reporting year.

Step 3: Convert to MT CO₂e and total emissions

Use Equation A-11 to convert to units of CO_2e and determine total F-gas emissions. GWP for each gas are in Appendix D.

Example A-10: Screening

Step 1: Determine base inventory

Screening Sample Data for Medium & Large Commercial Refrigeration

Quantity of HFC-23 charged into the new equipment	800 kg
Total full charge of the new equipment	400 kg
Time equipment was in use	1 yr
Total full charge of equipment being disposed	200 kg
Installation emission factor	3%
Operating emission factor	35%
Refrigerant remaining at disposal	100%
Recovery efficiency	70%

Step 2: Calculate annual emissions

Equation A-13 :
Annual Emissions (MT HFC-23) $= [(C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z))] \div 1{,}000$ (kg/metric ton)

$$= [(800 \text{ kg} \bullet 3\%) + (400 \text{ kg} \bullet 35\% \bullet 1) + (200 \text{ kg} \bullet 100\% \bullet (1\text{-}70\%))] \div$$

$$1{,}000 \text{ kg/MT}$$
$$= 0.2244 \text{ MT HFC-23}$$

Where:
C_N = quantity of F-gas charged into the new equipment (kg).
k = installation emission factor (%).
C = total full charge (capacity) of the equipment (kg).
x = operating emission factor (%).
T = time equipment was in use (e.g., 0.5 if used only during half the year and then disposed) (yrs).
C_D = total full charge (capacity) of equipment being disposed (kg).
y = refrigerant remaining at disposal.
z = recovery efficiency.

Step 3: Convert to MT CO₂e and total emissions

Equation A-11:
CO₂e (MT F-gas) = Annual Emissions (MT) $\bullet$ F-gas GWP
$= 0.2244 \text{ MT} \bullet 11{,}700$
$= 2{,}625.48 \text{ MT CO}_2e$

A.6 Fugitive Emissions - Wastewater Treatment

Description

This category includes emissions from the transportation, disposal and/or treatment of wastewater generated as a result of operations. Wastewater treatment plant (WWTP) processes can produce anthropogenic CH_4, N_2O, and in some cases, CO_2, emissions. Wastewater from domestic (municipal sewage) and industrial sources is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants.

This section focuses solely on calculating the CH_4 and N_2O emissions created by centralized wastewater treatment and septic systems. GHG emissions from other activities related to wastewater treatment are currently not included in the Guidance.

The minimum required method is less data intensive, requiring only data on the population served by the wastewater treatment plant. These equations will be embedded in the GHG reporting portal. The detailed methodology uses facility level data.[25]

A.6.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

If agencies cannot obtain site-specific data, they can default to population based calculations.

Table A-11: Wastewater Treatment Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Type of WWTP	• Default provided	• Waste disposal division
Population served	• Agency Records	• Agency Records

The minimum required methodology divides sources of CH_4 and N_2O emissions into six categories, as shown in Table A-12. Agencies may use more than one of these processes.

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[25] Both the minimum required and detailed calculation methodologies are based on The Climate Registry's Local Government Operations Protocol (TCR-LGOP), Chapter 10. Agencies should be aware that because there is no widely accepted methodology for calculating emissions associated with wastewater treatment and TCR-LGOP is not from a federal source, these calculation methodologies may change in future versions of this Technical Support Document. The TCR-LGOP can be found at:
http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

Table A-12: Summary of Wastewater Treatment Emission Sources

GHG source	GHG type	Data Required	Equation
Incomplete combustion of digester gas at a centralized WWTP with anaerobic digestion of biosolids	Stationary CH_4 emissions	• Population served	A-14
Anaerobic and facultative treatment lagoons	Fugitive CH_4 emissions	• Population served	A-15
Septic systems	Fugitive CH_4 emissions	• Population served	A-16
Centralized WWTP with nitrification/denitrification	Fugitive N_2O emissions	• Population served	A-17
Centralized WWTP without nitrification/ denitrification	Fugitive N_2O emissions	• Population served	A-18
Effluent discharge to receiving aquatic environments	Fugitive N_2O emissions	• Population served	A-19

Calculation Steps

1. Determine which wastewater treatment processes are used

2. Calculate emissions from each wastewater treatment process that is used

3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used

The emissions from WWTPs are highly dependent upon the wastewater treatment processes that are used. Agencies should work with their waste disposal division to determine which of the processes outlined in Table A-12 are used by the agency.

Step 2: Calculate emissions from each wastewater treatment process that is used

Once an agency has determined which wastewater treatment processes it uses, it should next calculate emissions associated with each process by imputing population information into the GHG reporting portal.

This section is subdivided into the six processes outlined in Table A-12. Each sub-section provides a brief description of the process and the associated calculations that are part of the GHG reporting portal.

Stationary CH₄ from incomplete combustion of digester gas – Centralized WWTP with anaerobic digestion

Many agencies use anaerobic digesters to treat excess biosolids produced by the wastewater treatment process. Anaerobic digestion creates CH_4, which is then combusted. Due to small, but inherent inefficiencies, these treatment processes are a source of CH_4 and N_2O emissions. If site-specific data is unavailable, agencies should use Equation A-14.

Equation A-20 should be used by agencies that collect measurements of the volume of digester gas (biogas) produced and the fraction of CH_4 in their biogas in accordance with local, state, and/or federal regulations or permits, or published industry standardized sampling and testing methodologies (e.g., 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, EPA, etc.)

Equation A-14: Stationary CH₄ from Incomplete Combustion of Digester Gas (population served data)

Annual CH₄ emissions (metric tons) =

P ● Digester Gas ● F CH_4 ● ρ(CH_4) ● (1-DE) ● 0.0283 ● 365.25 ● 10^{-6}

Where:

P = population serviced by the WWTP with anaerobic digesters.

Digester Gas = measured standard cubic feet of digester gas produced per day [ft^3/day] = Default value of 1.0.

F CH_4 = measured fraction of CH_4 in biogas = Default value of 0.65.

P(CH_4) = density of methane at standard conditions [g/m^3] = Default value of 662.00.

DE = CH_4 Destruction Efficiency = Default value of 0.99.

0.0283 = conversion from ft^3 to m^3 [m^3/ft^3].

365.25 = conversion factor [day/year].

10^{-6} = conversion from g to metric ton [metric ton/g].

Source: EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2006,* Chapter 8, 8-9 (2008).

Fugitive Emissions from Wastewater Treatment Lagoons

Agencies can account for industrial wastewater emissions by adjusting the population served in Equation A-15 to account for the industrial contribution. The industrial-equivalent population is calculated based on the total biological oxygen demand (BOD)₅ discharged by industry to the municipal treatment system, expressed in kg of total BOD_5 per day divided by the BOD_5 population equivalent of 0.090 kg BOD_5/person/day.

The industrial-equivalent population is then added to the domestic population served by the centralized wastewater treatment system, and the total population (domestic plus industrial-equivalent) is the value agencies should use in Equation A-15, as appropriate.

If significant industrial contributions of BOD_5 are discharged to the treatment lagoons, agencies should use Equation A-21. Equation A-21 should be used by agencies that have wastewater treatment lagoons and collect measurements of the average BOD_5 load, BOD_5 removal in primary treatment upstream of the lagoon (if primary treatment is present), and the fraction of

overall lagoon removal performance in accordance with local, state and/or federal regulations or permits, or published industry standardized sampling and testing methodologies (e.g., 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, EPA, etc.).

Equation A-15: Fugitive CH₄ from Wastewater Treatment Lagoons (population served data)

Annual CH₄ emissions (metric tons) =

$P \bullet BOD_5 \text{ load} \bullet (1-F_P) \bullet Bo \bullet MCF_{anaerobic} \bullet F_{removed} \bullet 365.25 \bullet 10^{-3}$

Where:

P = Population served by lagoons adjusted for industrial discharge, if applicable [person].

BOD_5 load = amount of BOD_5 produced per day (influent to wastewater treatment process) [kg BOD_5/day] = Default value 0.090.

F_P = fraction of BOD_5 removed in primary treatment, if present = Default value 0.3*.

Bo = maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed] = Default value 0.6.

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems = Default value 0.8.

$F_{removed}$ = fraction of overall lagoon BOD_5 removal performance = Default value 1.0.

365.25 = Conversion factor [day/year].

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

*F_P: Tchobanoglous, G., F.L. Burton, and H.D. Stensel, *Wastewater Engineering: Treatment and Reuse*, p. 473, 4th Edition (2003).

Fugitive Emissions from Septic Systems

If your agency exercises operational control of septic systems, use the appropriate equation below to estimate the fugitive CH_4 from this emission source. If this site-specific data is not available, agencies should use Equation A-16 to estimate emissions from septic systems.

Equation A-22 should be used when measurements of the average BOD_5 load are collected in accordance with local, state and/or federal regulations or permits, or published industry standardized sampling and testing methodologies (e.g., 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, EPA, etc.).

Equation A-16: Fugitive CH₄ from Septic Systems (population served data)

Annual CH₄ emissions (metric tons) =

$P \bullet BOD_5 \text{ load} \bullet Bo \bullet MCF_{septic} \bullet 365.25 \bullet 10^{-3}$

Where:

P = Population served by septic systems [person].

BOD_5 load = amount of BOD_5 produced per day [kg BOD_5/day] = Default value = 0.090.

Bo = maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed] = Default value 0.6.

MCF_{septic} = CH_4 correction factor for anaerobic systems = Default value 0.5.

365.25 = Conversion factor [day/year].

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

Fugitive N₂O Emissions from a centralized WWTP with or without nitrification / denitrification

This section provides equations for calculating N_2O emissions from a centralized WWTP with nitrification / denitrification, centralized WWTP without nitrification / denitrification, and effluent discharge to receiving aquatic environments. They are adapted for use by agencies from Section 6.3 of the 2006 *IPCC Guidelines* and Section 8.2 of the *U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (1990-2006).* For each term in the equations, this section provides a description and an appropriate value.

This industrial equivalent population is added to the domestic populations served by the centralized wastewater treatment system and the total population (domestic plus industrial equivalent) is the value agencies should use in Equation A-17 and Equation A-18, as appropriate.

Please note that in Equation A-23 and Equation A-24, the population served needs to be modified to include contributions from industry if significant industrial contributions of nitrogen are discharged to your municipal treatment system. The equivalent population from industry is calculated based on the total nitrogen discharged by industry to the municipal treatment system, expressed in kg of total nitrogen per day divided by the nitrogen population equivalent of 0.026 kg N/person/day.

**Equation A-17: Fugitive N₂O Emissions from WWTP with
Nitrification / Denitrification**

Annual N_2O emissions (metric tons) =
P_{total} ● $EF_{nit/denit}$ ● 10^{-6}

Where:
P_{total} = Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person].
$EF_{nit/denit}$ = Emission factor for a WWTP with nitrification/denitrification [g N_2O/person/year] = Default value 7.0.
10^{-6} = Conversion from g to metric ton [metric ton/g].

**Equation A-18: Fugitive N₂O Emissions from WWTP without
Nitrification/Denitrification**

Annual N_2O emissions (metric tons) =
P_{total} ● $EF_{w/o\ nit/denit}$ ● 10^{-6}

Where:
P_{total} = Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person].
$EF_{w/o\ nit/denit}$ = Emission factor for a WWTP without nitrification/denitrification [g N_2O/person/year] = Default value 3.2.
10^{-6} = Conversion from g to metric ton [metric ton/g].

Fugitive Emissions from Effluent Discharge to Rivers and Estuaries

If this site-specific data is not available, agencies should use Equation A-19 to estimate Fugitive N_2O emissions from effluent discharge.

If significant industrial contributions of nitrogen are discharged to the treatment system used by an agency, the agency should use Equation A-19 Alternatively; the agency can adjust the population served in Equation A-19 to account for the industrial contribution. The industrial-equivalent population is calculated based on the total nitrogen discharged by industry to the municipal treatment system, expressed in kg of total nitrogen per day divided by the nitrogen population equivalent of 0.026 kg N/person/day.

The industrial-equivalent population is added to the domestic populations served by the centralized wastewater treatment system, and the total population (domestic plus industrial-equivalent) is the value agencies should use in Equation A-19, as appropriate.

Equation A-25 should be used by agencies whose wastewater operators collect measurements of the average total nitrogen discharged in accordance with local, state and/or federal regulations or permits, or published industry standardized sampling and testing methodologies (e.g., 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, EPA, etc.).

Equation A-19: Fugitive N_2O Emissions from Effluent Discharge
(population served data)

Annual N_2O emissions (metric tons) =
P_{total} ● (Total N Load - N uptake ● BOD_5 load) ● EF effluent ● 44/28 ●(1 - F plant nit/denit) ● 365.25 ● 10^{-3}

Where:

P_{total} = Population served adjusted for industrial discharge, if applicable [person].

Total N Load[26] = Total nitrogen load [kg N/person/day] = Default value 0.026.

N uptake[27] = Nitrogen uptake for cell growth in aerobic system/anaerobic system (kg N/kg BOD_5) = Default values 0.05^1 for aerobic and 0.005^1 for anaerobic.

BOD_5 load = Amount of BOD_5 produced per person per day [kg BOD_5/person/day] = Default value 0.090.

44/28 = Molecular weight ratio of N_2O to N_2.

F plant nit/denit = Fraction of nitrogen removed for the centralized WWTP with nit/denit = Default value 0.7^1.
          or, Fraction of nitrogen removed for the centralized WWTP w/o nit/denit = Default value 0.0^1.

365.25 = Conversion factor [day/year].

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

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[26] The default total nitrogen load value is derived based on the following default values from U.S. EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, Chapter 8, 8-14 and Table 8.11: Average U.S. protein intake (41.9 kg/person-year) x default fraction of N in protein (0.16 kg N/kg protein) x factor for non-consumed protein added to water (1.4) / days per year (365.25) = 0.026 kg N/person/day.

[27] Some of the influent nitrogen is required for microbial growth inherent in aerobic or anaerobic treatment processes. Nitrogen is assimilated by bacteria, which grow and are further managed as biosolids. This assimilation results in lower nitrogen levels in the discharged effluent.

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[1] Grady, C. P. L., Jr., G. T. Daigger, and H. C. Lim, *Biological Wastewater Treatment*, p. 108-109, 644 2nd Edition (1999).

Step 3: Sum emissions from all processes

Agencies should sum the emissions from all processes and apply the appropriate GWPs to calculate total emissions from wastewater treatment in units of CO_2e.

Equation A-4: Wastewater MT CO₂e Emissions

CO_2e **Emissions (MT CO_2e) =** $(MT\ N_2O \bullet GWP\ N_2O) + (MT\ CH_4 \bullet GWP\ CH_4)$

A.6.2 Detailed Methodology (User Calculated)

Data Sources

The detailed methodology uses facility level data.

Table A-13: Wastewater Treatment Detailed Data Sources

Data Element	Preferred Source
Wastewater treatment processes used	• Waste disposal division
Digester gas (ft^3/day)	• Waste disposal division
Fraction of CH_4 in biogas	• Waste disposal division
BOD_5 load (kg BOD_5/day)	• Waste disposal division
Fraction of overall BOD_5 removal performance	• Waste disposal division
N load	• Waste disposal division
Population served	• Agency Records

The method divides sources of CH_4 and N_2O emissions into six categories. Agencies should note that they may use more than one of these processes.

Table A-14: Summary of Wastewater Treatment Emission Sources

GHG source	GHG type	Data Required	Equation
Incomplete combustion of digester gas at a centralized WWTP with anaerobic digestion of biosolids	Stationary CH_4 emissions	• Digester gas (ft3/day) • Fraction of CH_4 in biogas	A-20
Anaerobic and facultative treatment lagoons	Fugitive CH_4 emissions	• BOD_5 load (kg BOD_5/day) • Fraction of overall BOD_5 removal performance	A-21

Septic systems	Fugitive CH_4 emissions	BOD_5 load (kg BOD_5 / person / day)	A-22
Centralized WWTP with nitrification/denitrification	Fugitive N_2O emissions	Population served	A-23
Centralized WWTP without nitrification/denitrification	Fugitive N_2O emissions	Population served	A-24
Effluent discharge to receiving aquatic environments	Fugitive N_2O emissions	N load (kg N/day)	A-25

Calculation Steps

1. Determine which wastewater treatment processes are used

2. Calculate emissions from each wastewater treatment process that is used

3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used

The emissions from WWTPs are highly dependent upon the wastewater treatment processes that are used. Agencies should work with their waste disposal division to determine which of the processes outlined in Table A-14 are used by the agency.

If agencies are unable to determine which wastewater treatment processes are used, they should defer to the alternative methodology.

Step 2: Calculate emissions from each wastewater treatment process that is used

Once an agency has determined which wastewater treatment processes it uses, it should next calculate emissions associated with each process. See the minimum required methodology for more detail on each source.

Equation A-20: Stationary CH₄ from Incomplete Combustion of Digester Gas (site-specific data

Annual CH₄ emissions (metric tons) =
Digester Gas ● FCH_4 ● $\rho(CH_4)$ ● (1-DE) ● 0.0283 ● 365.25 ● 10^{-6}

Where:

Digester Gas = measured standard cubic feet of digester gas produced per day [ft^3/day].

F CH_4 = measured fraction of CH_4 in biogas.

$P(CH_4)$ = density of methane at standard conditions [g/m^3] = Default value of 662.00.

DE = CH_4 Destruction Efficiency = Default value of 0.99.

0.0283 = conversion from ft^3 to m^3 [m^3/ft^3].

365.25 = conversion factor [day/year].

10^{-6} = conversion from g to metric ton [metric ton/g].

Source: EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2006,* Chapter 8, 8-9 (2008).

Equation A-21: Fugitive CH₄ from Anaerobic and Facultative Wastewater Treatment Lagoons (site-specific data)

Annual CH₄ emissions (metric tons) =
BOD_5 load ● (1-F_P) ● Bo ● $MCF_{anaerobic}$ ● $F_{removed}$ ● 365.25 ● 10^{-3}

Where:

BOD_5 load = amount of BOD_5 produced per day (influent to wastewater treatment process) [kg BOD_5/day].

F_P = fraction of BOD_5 removed in primary treatment, if present.

Bo = maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed] = Default value 0.6.

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems = Default value 0.8.

$F_{removed}$ = fraction of overall lagoon BOD_5 removal performance.

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

Equation A-22: Fugitive CH₄ from Septic Systems (site-specific data)

Annual CH₄ emissions (metric tons) =
BOD_5 load ● Bo ● MCF_{septic} ● 365.25 ● 10^{-3}

Where:

BOD_5 load = amount of BOD_5 produced per day [kg BOD_5/day].

Bo = maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed] = Default value 0.6.

MCF_{septic} = CH_4 correction factor for anaerobic systems = Default value 0.5.

365.25 = Conversion factor [day/year].

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

Equation A-23: Fugitive N_2O Emissions from WWTP with Nitrification / Denitrification

Annual N_2O emissions (metric tons) =
$P_{total} \bullet EF_{nit/denit} \bullet 10^{-6}$

Where:

P_{total} = Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person].

$EF_{nit/denit}$ = Emission factor for a WWTP with nitrification / denitrification [g N_2O/person/year] = Default value 7.0.

10^{-6} = Conversion from g to metric ton [metric ton/g].

Equation A-24: Fugitive N_2O Emissions from WWTP without Nitrification/Denitrification

Annual N_2O emissions (metric tons) =
$P_{total} \bullet EF_{w/o\ nit/denit} \bullet 10^{-6}$

Where:

P_{total} = Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person].

$EF_{w/o\ nit/denit}$ = Emission factor for a WWTP without nitrification / denitrification [g N_2O/person/year] = Default value 3.2.

10^{-6} = Conversion from g to metric ton [metric ton/g].

Equation A-25: Fugitive N_2O Emissions from Effluent Discharge (site-specific data)

Annual N_2O emissions (metric tons) =
N Load $\bullet$ EF effluent $\bullet$ 365.25 $\bullet$ 10^{-3}

Where:

N Load = Measured average total nitrogen discharge [kg N/day].

EF effluent = Emission factor [kg N_2O-N/kg sewage-N produced] = Default value 0.005.

365.25 = Conversion factor [day/year].

10^{-3} = Conversion from kg to metric ton [metric ton/kg].

Step 3: Sum emissions from all processes

Agencies should sum the emissions from all processes and apply the appropriate GWPs to calculate total emissions from wastewater treatment in units of CO_2e.

Equation A-4: Wastewater MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) =
(MT N_2O $\bullet$ GWP N_2O) + (MT CH_4 $\bullet$ GWP CH_4)

Example A-11: Wastewater Treatment

An agency's wastewater treatment facility combusts digester gas and has a nitrification / denitrification process. The facility serves 10,000 people, and the agency does not have any site specific data on the facility.

Step 1: Determine which wastewater treatment processes are used

The WWTP uses incomplete combustion of digester gas and nitrification / denitrification.

Step 2: Calculate emissions from each wastewater treatment process used

Equation A-14: Stationary CH_4 from Incomplete Combustion of Digester Gas (population served data)

Annual CH_4 emissions (MT) $= P \bullet \text{Digester Gas} \bullet F\ CH_4 \bullet \rho(CH_4) \bullet (1\text{-}DE) \bullet 0.0283 \bullet 365.25 \bullet 10^{-6}$

$$= 10,000 \bullet 1 \bullet 0.65 \bullet 662 \bullet (1\text{-}0.99) \bullet 0.0283 \bullet 365.25 \bullet 10^{-6}$$

$$= 0.44$$

Where:

P = population serviced by the WWTP with anaerobic digesters.

Digester Gas = measured standard cubic feet of digester gas produced per day [ft^3/day] = Default value of 1.0.

$F\ CH_4$ = measured fraction of CH_4 in biogas = Default value of 0.65.

$P(CH_4)$ = density of methane at standard conditions [g/m^3] = Default value of 662.00.

DE = CH_4 Destruction Efficiency = Default value of 0.99.

0.0283 = conversion from ft^3 to m^3 [m^3/ft^3].

365.25 = conversion factor [day/year].

10^{-6} = conversion from g to metric ton [metric ton/g].

Equation A-17: Process N_2O Emissions from WWTP with Nitrification / Denitrification

Annual N_2O emissions (MT) $= P_{total} \bullet EF_{nit/denit} \bullet 10^{-6}$

$$= 10,000 \bullet 7.0 \bullet 10^{-6}$$

$$= 0.07$$

Where:

P_{total} = Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person].

$EF_{nit/denit}$ = Emission factor for a WWTP with nitrification / denitrification [g N_2O/person/year] = Default value 7.0.

10^{-6} = Conversion from g to metric ton [metric ton/g].

Step 3: Sum emissions from all processes

Equation A-4: Wastewater MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) $= (MT\ N_2O \bullet GWP\ N_2O) + (MT\ CH_4 \bullet GWP\ CH_4$

$$= 0.44 * 21 + 0.07 * 310$$

$$\textbf{= 30.94 MT } CO_2e$$

A.7 Fugitive Emissions - Landfills and Solid Waste Facilities

Description

This category includes emissions from the disposal and/or treatment of wastes generated as a result of operations.

Disposal of wastes (landfilling, combustion) results in potentially significant GHG emissions. Landfilling of organic wastes results in anaerobic decomposition and methane generation, a greenhouse gas with a higher global warming potential than CO_2. Combustion of this landfill gas (LFG) constitutes disposal and releases fossil based CO_2 emissions.

A.7.1 Minimum Required Methodology (User Calculated by LandGEM Tool)

Data Sources

The minimum required approach for calculating solid waste emissions is based upon both the U.S. EPA's Landfill Gas Emissions Model (LandGEM)[28] and their Climate Leader's Offset Project Methodology. This methodology was developed to be highly flexible to enable agency use of their facility level data, when available, but to also provide default values if facility level data is unavailable to the agency.

Before performing the detailed site-specific calculations, any agency applying this methodology must first determine if their landfills in their operational control have LFG collection systems. If they do not, agencies need only apply the methodology approach outlined in Step 1. However, if one or more of the agency's landfills have an LFG collection system, they should use apply both Steps 1 and 2 to the respective landfills. If agencies are unsure whether their landfill has an LFG collection system, Step 2 enables the agency to apply a national average factor until more detailed information is made available.

1. Utilize EPA's LandGEM model to calculate CH_4 and CO_2 generation
2. Calculate emission reductions from capture and combustion of LFG

Table A-15: Scope 1 Fugitive Emissions from Solid Waste/Landfills

Data Element	Preferred Source	Alternate Source
Does the landfill have a LFG collection system?	If unknown, assume no LFG collection system.	Waste disposal division
Mass of solid waste disposed		Reporting to OFEE under EO 13423, Sec. 2(e)
GWP	Appendix D	
Landfill open year and close year	Default provided by GHG	Waste disposal division

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[28] The EPA LandGEM model can be found at: http://www.epa.gov/ttn/catc/dir1/landgem-v302.xls.
The LandGEM user guide can be found at: http://www.epa.gov/ttncatc1/dir1/landgem-v302-guide.pdf.

		reporting portal	
Methane concentration rate, k		Default provided by portal	Waste disposal division
Potential methane generation capacity, Lo		Default provided by GHG reporting portal	Waste disposal division
NMOC concentration, ppmv		Default provided by GHG reporting portal	Waste disposal division
Methane content of LFG, % by volume		Default provided by GHG reporting portal	Waste disposal division
If LFG collection system	Efficiency of LFG collection system	Waste disposal division	
	Oxidation factor	Waste disposal division	

Calculation Steps[29]

Step 1: Use EPA's LandGEM model to calculate CH_4 and CO_2 generation

Step 1 utilizes the EPA's LandGEM[1] model that is already in well established for regulatory reporting purposes. This automated tool uses a Microsoft Excel interface to enter the requisite data necessary to estimate the emission rates for total landfill gas, methane, carbon dioxide, non-methane organic compounds, and individual air pollutants from municipal solid waste landfills. It should be noted that this model does not consider emission reductions from LFG capture.

The LandGEM model requires agency users to input the annual deposition of solid waste, landfill open year, and its closure year (if applicable). The model provides default values for methane concentration rate, potential methane generation capacity, NMOC concentration, and methane content of LFG. However, agencies are encouraged to use site-specific data for these data elements if they are available at the facility level.

LandGEM calculates how the deposition of waste in a given year will result in anthropogenic CH_4 and biogenic CO_2 emissions over time. Although the emissions from one year's solid waste disposal generates GHGs for several years, the limits of the agencies scope 1 GHG inventories necessitate that only the facility's annual emissions be included in scope 1 for that fiscal year's GHG inventory.

Step 2: Calculate emission reductions from capture and combustion of LFG

Step 2 is required for agencies operationally control waste facilities that are equipped with LFG capture and combustion systems as well as for agencies unsure whether their waste facilities have LFG capture and combustion systems.

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[29] Primary Reference: U.S. EPA Climate Leaders, Direct Emissions from Municipal Solid Waste Landfilling, October 2004 and U.S. EPA TSD for the Landfill Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

As the current version of the LandGEM model does not calculate emission reductions from LFG capture and combustion, the Climate Leaders "Greenhouse Gas Inventory Protocol, Offset Project Methodology" guide is to be used to help calculate these CH_4 reductions.

This step requires three additional pieces of information:

1. Amount of CH_4 and CO_2 generated (i.e., output from LandGEM model);
2. LFG collection system efficiency (default provided); and
3. Oxidation factor (default provided).

Once an agency determines that their landfill has an LFG collection system, they should use Equation A-26. Agencies unsure whether their landfill has an LFG collection system, should use Equation A-27. Equation A-27 applies a national average factor for percent of solid waste facilities with LFG capture systems. This national average factor is based upon information in the EPA Climate Leaders "Greenhouse Gas Inventory Protocol Offset Project Methodology".

Equation A-26: Emissions from Solid Waste Facilities with LFG Capture Systems

CO_2e Emissions (MT) = (CH_{4gen} ● GWP_{CH4} ● (1 – OF ● $\eta_{LFGsystem}$) + CH_{4gen} (1 – OF * $\eta_{LFGsystem}$) * (22/10) + CO_{2gen}) ÷ 1,000

Where:

CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [kg].

CO_{2gen} = CO_2 generated by landfill, calculated in LandGEM [kg].

CO_2e = CO_2e generated by landfill after capture and combustion of CH_4 [metric tons].

GWP_{CH4} = Global Warming Potential of CH_4 [unitless].

$\eta_{LFGsystem}$ = Efficiency of LFG collection system [%] Default value = 0.75.

OF = Oxidation factor [unitless] Default value = 0.90.

Source: Climate Leaders, Greenhouse Gas Inventory Protocol Offset Project Methodology.

Equation A-27: Emissions from Solid Waste Facilities if the Presence of an LFG System is Unknown

CO_2e Emissions (MT) = (CH_{4gen} ● GWP_{CH4} ● (1 – 0.50 ● 0.90 ● 0.75) + CH_{4gen} (1 – 0.90 * 0.75) * (22/10) + CO_{2gen}) ÷ 1,000

Where:

CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [kg].

CO_{2gen} = CO_2 generated by landfill, calculated in LandGEM [kg].

CO_2e = CO_2e generated by landfill after capture and combustion of CH_4 [metric tons].

GWP_{CH4} = Global Warming Potential of CH_4 [unitless].

Source: Climate Leaders, Greenhouse Gas Inventory Protocol Offset Project Methodology.

Example A-12: Solid Waste Management

An agency knows their solid waste facility has an LFG collection system. The agency inputs the mass of solid waste they dispose annually, the facility's open/close dates, and other known factors into the LandGEM model. The LandGEM model outputs that the waste generates 1,000 kg of CH_4 and 1,000 kg of CO_2. As no site specific data is available, the agency uses available default values for all of these steps. Standard collection efficiency is 0.75, and oxidation factor is 0.90.

Step 1: Use EPA's LandGEM model to calculate CH_4 and CO_2 generation

Step 2: Calculate emission reductions from capture and combustion of LFG

Equation A-26: Emissions from Solid Waste Facilities with LFG Capture Systems

$$CO_2e \text{ Emissions (MT)} = (CH_{4gen} \bullet GWP_{CH4} \bullet (1 - OF \bullet \eta_{LFGsystem}) + CH_{4gen} (1 - OF * \eta_{LFGsystem}) * (22/10) + CO_{2gen}) \div 1,000$$

$$= (1,000 \text{ kg} \bullet 21 \bullet (1 - 0.90 \bullet 0.75) + 1,000 \text{ kg} \bullet (1 - 0.90 \bullet 0.75) \bullet (22/10) + 1,000 \text{ kg}) \div 1,000$$

$$= 8.54 \text{ MT } CO_2e$$

Where:

CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [kg].

CO_{2gen} = CO_2 generated by landfill, calculated in LandGEM [kg].

CO_2e = CO_2e generated by landfill after capture and combustion of CH_4 [metric tons].

GWP_{CH4} = Global Warming Potential of CH_4 [unitless].

$\eta_{LFGsystem}$ = Efficiency of LFG ccollection system [%] Default value = 0.75.

OF = Oxidation factor [unitless] Default value = 0.90.

A.8 Industrial Process Emissions

Most agencies will not have fugitive emissions beyond those identified above. If the agency owns and/or operates industrial sources of GHG emissions, below are guidelines that can be used to calculate their process emissions. All references to the IPCC 2006 Guidelines are to Volume 3 of those Guidelines, *Industrial Processes and Product Use*.

- Adipic acid production (process N_2O emissions)

  - EPA MRR Technical Support Document: 40 Code of Federal Regulations (CFR) Part 98 Subpart E

  - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.8

  - WRI/WBCSD, Calculating N_2O Emissions from the Production of Adipic Acid, 2001

- Aluminum production (process CO_2 and PFC emissions)

- o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart F

- o CO_2: IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.21-4.24

- o PFCs: IPCC 2006 Guidelines, Volume 3, Chapter 4,Equations 4.25-4.27

- Ammonia production (process CO_2 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart G

  - o IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.3

- Cement production (process CO_2 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart H

  - o California Air Resources Board, Draft Regulation for the Mandatory Reporting of Greenhouse Gas Emissions, 2008

  - o California Climate Action Registry Cement Reporting Protocol, 2005

  - o Cement Sustainability Initiative, The Cement CO_2 Protocol: CO_2 Accounting and Reporting Standard for the Cement Industry (2005) Version 2.0

- HCFC-22 production (process HFC-23 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart O

  - o IPCC 2006 Guidelines, Volume 3, Chapter 3, Equations 3.31 - 3.33

  - o WRI/WBCSD, Calculating HFC-23 Emissions from the Production of HCFC-22, 2001

- Iron and steel production (process CO_2 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart Q

  - o IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.9 - 4.11.

- Lime production (process CO_2 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart S

  - o IPCC 2006 Guidelines, Volume 3, Chapter 2, Equation 2.5 - 2.7

- Nitric acid production (process N_2O emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart V

- o IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.6

- o WRI/WBCSD, Calculating N_2O Emissions from the Production of Nitric Acid, 2001

- Particle accelerators (SF_6 emissions)

  - o IPCC 2006 Guidelines, Volume 3, Chapter 8, Equation 8.17

- Pulp and paper production (process CO_2 emissions)

  - o EPA MRR Technical Support Document: 40 CFR Part 98 Subpart AA

  - o IPCC 2006 Guidelines, Volume 3, Chapter 2, Section 2.5

  - o International Council of Forest and Paper Associations (ICFPA), Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills, Version 1.1, 2005

- Refrigeration and air condition equipment manufacturing (process HFC and PFC emissions)

  - o U.S. EPA Climate Leaders, Direct HFC and PFC Emissions from Manufacturing Refrigeration and Air Conditioning Units, 2003

  - o WRI/WBCSD, Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration & Air-conditioning Equipment (Version 1.0) 2005

- Semiconductor manufacturing (process PFC and SF_6 emissions)

  - o IPCC 2006 Guidelines, Equations 6.7 - 6.11

Appendix B – Calculating Scope 2 Emissions

As detailed in Chapter 2 of the Guidance, scope 2 emissions are indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. They are a consequence of activities occurring within the agency's boundaries, but are emitted at sources owned or controlled by another entity. This appendix also includes calculation methodology for the purchase of RECs because they can be used to reduce scope 2 emissions.

This section provides calculation methodologies for:

- Purchased electricity
- Purchased steam or hot water and chilled water
- Electricity, steam or hot water purchases from a Combined Heat & Power Facility
- Steam purchases from a MSW Waste-to-Energy Facility
- Reductions from RECs

B.1 Purchased Electricity

Description

Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company.

B.1.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

Data from scope 2 GHG emissions are primarily calculated from metered electricity consumption and published emission factors. Table B-1 shows the minimum required methodology and the data it requires.

Table B-1: Purchased Electricity Minimum Required Data Sources

Data Element	Preferred Source
Purchased Electricity	• Annual Energy reporting [MWh] or purchasing records [MWh] by eGRID subregion
Emission Factor	• Standardized emission factors provided in Appendix D

Calculation Steps[30]

To calculate scope 2 emissions from electricity use:

1. Determine annual electricity use from all facilities within agency's organizational boundary;

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[30] Local Government Operating Protocol.

2. Select the appropriate emission factors that apply to the electricity used; and

3. Determine the total annual emissions in metric tons of CO_2e.

Step 1: Determine annual electricity use from all facilities within agency's operational control

Electricity use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the Guidance. Electricity use should be reported by the corresponding NERC subregion and align with the agency's annual energy consumption reporting to the DOE. Agencies should refer to [Federal Energy Management Guidance[31]] for guidance on preferred sources for electricity use data (i.e., metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available.

Step 2: Select the appropriate emission factors that apply to the electricity used

The electricity emission factor represents the amount of GHGs emitted per unit of electricity consumed. It is usually reported in units of pounds of GHG per MWh or GWh.

The eGRID subregion emission factors will be used to provide a consistent, verifiable basis for emissions calculations. Because emission factors vary by location, agencies should be sure to use the appropriate region-specific factors for each facility. Because eGRID is updated periodically, agencies should use the eGRID emission rates corresponding to the year of their inventory activity data. For example, an FY 2008 inventory should be based on 2008 eGRID emission rate factors, if available. If eGRID emission rate data is not available for a certain year then the agency should use the most recent eGRID emission rate data until a new eGRID release. Agencies are not expected to retroactively update their inventories with new eGRID factors once the inventory has been submitted to CEQ. A map of eGRID regions and list of emission factors can be found in Appendix E and at http://epa.gov/cleanenergy/energy-resources/egrid/index.html.

Step 3: Determine total annual emissions in metric tons of carbon dioxide equivalent

To determine annual emissions, multiply annual electricity use in MWh (Step 1) by the emission factors for CO_2, CH_4, and N_2O in pounds per MWh (Step 2).

Equation B-1: Calculating Indirect Emissions from Electricity Use

CO_2 Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs CO_2/MWh) ÷ 2,204.62 (lbs/metric ton)
CH_4 Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs CH_4/MWh) ÷ 2,204.62 (lbs/metric ton)
N_2O Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs N_2O/MWh) ÷ 2,204.62 (lbs/metric ton)

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[31] http://www1.eere.energy.gov/femp/regulations/guidance.html.

To convert CH_4 and N_2O into units of CO_2e, multiply total emissions of each gas (in metric tons) by its IPCC global warming potential (GWP) factor provided in Appendix B. Then sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-2: Converting to CO_2e and Determining Total Emissions

CO_2 Emissions (metric tons CO_2e) = CO_2 Emissions (metric tons) • 1 (GWP)
CH_4 Emissions (metric tons CO_2e) = CH_4 Emissions (metric tons) • 21 (GWP)
N_2O Emissions (metric tons CO_2e) = N_2O Emissions (metric tons) • 310 (GWP)
Total Emissions (metric tons CO_2e) = CO_2 + CH_4 + N_2O (metric tons CO_2e)

Transmission and Distribution Losses

If the agency purchases (rather than generates) electricity and transports it through a T&D system that it owns or controls, report the emissions associated with T&D losses under scope 2. End consumers of the purchased electricity do not report indirect emissions associated with T&D losses in scope 2 because they do not own or control the T&D operation, where the electricity is consumed. To estimate these emissions, see Appendix D Scope 3 Emissions.

Example B-1: Purchased Electricity

Reporting scope 2 emissions from electricity consumption begins by determining annual electricity use at each agency. This agency in eGrid section SRVC located all the monthly energy statement for the year to determine the total amount of electricity consumed. The aggregate of the monthly electricity use is 30,000 MWh or the annual electricity use for the facility.

Step 1: Determine annual electricity use from all facilities within agency's operational control

Electricity use for this facility = 30,000 MWh

Step 2 Select the appropriate emission factors that apply to the electricity used

CO_2 = 1,134.88 (lb/MWh)
N_20 = 19.79 (lb/GWh) = 19.79 (lb/GWh) ÷1,000 = 0.01979 (lb/MWh)
CH_4 = 23.77 (lb/GWh) = 23.77 (lb/GWh) ÷1,000 = 0.02377 (lb/MWh)

Step 3: Determine total annual emissions in metric tons of carbon dioxide equivalent

CO_2 **Emissions** (metric tons) =
30,000 (MWh) • 1,134.88 (lbs CO_2/MWh) ÷ 2,204.62 (lbs/metric ton) = 15,443.21
CH_4 **Emissions** (metric tons) =
30,000 (MWh) • 0.02377 (lbs CH_4/MWh) ÷ 2,204.62 (lbs/metric ton) = 0.318
N_2O **Emissions** (metric tons) =
30,000 (MWh) • 0.01979 (lbs N_2O/MWh) ÷ 2,204.62 (lbs/metric ton) = 0.269

Convert CH_4 and N_2O into units of CO_2e,
CO_2 **Emissions** (metric tons CO_2e) = 15,443.21 (metric tons) • 1 (GWP) = 15,443.21
CH_4 **Emissions** (metric tons CO_2e) = 0.318 (metric tons) • 21 (GWP) = 6.678
N_2O **Emissions** (metric tons CO_2e) = 0.269 (metric tons) • 310 (GWP) = 83.39

Total Emissions (metric tons CO_2e) = CO_2 + CH_4 + N_2O (metric tons CO_2e) = 15533.27

B.1.2 Detailed Methodology (User Calculated) [32]

If metered electricity data is unavailable for an agency's buildings or facilities, there are three alternate approaches for estimating these scope 2 emissions:

1. Estimate electricity use for leased space based on the facility's total annual consumption,

2. Estimate electricity use based on proxy year data, or

3. Estimate electricity use based on known electricity use at comparable facilities.

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[32] Local Government Operating Protocol.

Data Sources

Scope 2 GHG emissions are primarily calculated from metered electricity consumption and published emission factors; however there are instances where an agency may not be able to obtain this information. Table B-2 presents the detailed methodologies available to estimate your emissions. These methods yield less accurate emission numbers as they are not specific to the space occupied by an agency.

Table B-2: Purchased Electricity Detailed Data Sources

Data Element	Preferred Source
Detailed Calculation Methodology: Estimated Electricity Use	
Total building area (square feet)	● Building Manager
Area of entity's space (square feet)	● Building Manager
Total building annual electricity use (kWh)	● Building Manager
Detailed Calculation Methodology: Proxy Year Electricity Use Data	
Electricity use from prior Years	● Annual Energy reporting; ● Electricity purchasing records
Heating and Cooling Degree Days	● National climate data center website
Detailed Calculation Methodology: Comparable Facilities and Square Footage	
Size of the facility measured in floor area (square feet)	● Building Manager
Identify comparable facilities with known annual electricity use and square footage	● Buildings Manager of comparable facilities

Alternative Methodology 1: Estimated Electricity Use

If purchase records, electricity bills, or meter readings are not available or applicable, an alternate method is to estimate electricity use based on the share of the building's floor space that is leased and the building's total electricity consumption. This method yields less accurate estimates than the recommended electricity use method because it is not specific to the particular space occupied in the building and assumes that all occupants of the building have similar energy consuming habits.

To use this method, the following information, is required

- Total building area (square feet);
- Area of entity's space (square feet);
- Total building annual electricity use (kWh); and
- Building occupancy rate (e.g., if 75 percent of the building is occupied, use 0.75).

Use this information and the equation below to estimate a facility's share of the building's electricity use.

Equation B-3: Estimating Electricity Use

Estimated Electricity Use (kWh) =
Entity's Area ÷ Building Area • Building Electricity Use ÷ Occupancy Rate
   [sq ft]   [sq ft]   [kWh]

Using this estimated electricity use follow the guidance in the recommended approach to estimate CO_2, CH_4, and N_2O scope 2 emissions from a facility.

Alternative Methodology 2: Proxy Year Data

If purchase records, electricity bills, or meter readings are not available, estimate energy consumption for a facility based on the energy consumed at the building or facility in another year. Typically this approach is used in cases of one or a few minor facilities. Generally, it should not be used as a substitute for a significant group of buildings or facilities or the entire buildings sector. Agencies should disclose the use of any proxy years in reporting as part of the calculation methodology disclosure.

The following steps estimate the annual electricity use at a facility:

1. Determine the electricity used in each facility in the proxy year; and
2. Normalize for heating and cooling degree days.

Step 1: Determine the electricity used in each facility in the proxy year.

The proxy year can be either another calendar year or else a fiscal year.

Step 2: Normalize for heating and cooling degree days.

Estimate the proportion of electricity used in a year for heating as a percentage of the total electricity consumed and the proportion of annual electricity used in a year for cooling as a percentage of the electricity consumed. This should be based on the increased electricity consumed during winter months and summer months respectively. Where monthly data is not available, the best recommendation of a facility manger may be used. Then, determine annual heating and cooling degree days in the region in the year being estimated and the proxy year. The national climate data center website provides information on the heating and cooling degree days by month and by state at: http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#.

Normalize for heating and cooling degree days using equation B-4.

Equation B-4: Normalizing for Heating Degree Days and Cooling Degree Days

Estimated energy consumed in inventory year (kWh)=
$[((EP \cdot Eh)/ DHP) \cdot (DHI/1)] + [((EP \cdot EC)/ DCP) \cdot (DCI/1)] + [(1 - Eh - EC) \cdot EP]$

Where:
EP = electricity used in proxy year (kWh).
Eh = percentage of electricity used for heating.
DHP = heating degree days in the proxy year.
DHI = heating degree days in inventory year.
EC = percentage of electricity used for cooling.
DCP = cooling degree days in the proxy year.
DCI = cooling degree days in inventory year.

Source: ICLEI Local Government Operating Protocol

Using the estimated electricity use calculated from the equation B-4, follow the recommended approach to estimate CO_2, CH_4, and N_2O scope 2 emissions from the facility.

Alternative Methodology 3: Comparable Facilities and Square Footage

Where actual electricity records are not available and total annual electricity consumption from the facility is unknown, estimate electricity based on the size and function of the facility.

Typically this approach is used in cases of one or a few minor facilities. Generally, it should not be used as a substitute for a significant group of buildings, facilities or the entire facilities sector. Agencies should disclose the use of any comparable facilities data in reporting as part of the calculation methodology disclosure.

Use the following steps to estimate the electricity use at the facility:

1. Determine the size of the facility measured in floor area (square feet);
2. Identify comparable facilities with known annual electricity use and square footage;
3. Determine electricity used per square foot at comparable facility; and
4. Estimate electricity used at facility.

Step 1: Determine the size of the facility measured in floor area (square feet)

Step 2: Identify comparable facilities with known annual electricity use rates and square footage

If possible these should be facilities owned or operated by the same government. The determination of comparability should include consideration of the primary function of the facility and the primary uses of electricity at each facility. Be sure to consider the age, hours of operation, number of occupants and the type of heating and cooling systems employed.

If electricity consumption for another comparable facility owned or operated by the agency is not available, consult the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey for average energy use by facility type and region of the country at http://www.eia.doe.gov/emeu/cbecs.

Step 3: Determine electricity used per square foot at comparable facility

Divide the annual electricity use at the comparable facility by its square footage to obtain a kWh/square foot coefficient.

Step 4: Estimate electricity used at facility

Multiply this coefficient by the area of the facility for which electricity use estimation is being completed for.

Equation B-5: Estimated Annual Electricity Use - Square Footage

Estimated Electricity Use (kWh) =   (Annual electricity use at comparable facility / Size of comparable facility) • Size of facility being estimated   (kWh)   (sq. ft.)   (sq. ft.)

Now use the estimated electricity use from equation above to follow the guidance in the recommended approach to estimate your CO_2, CH_4, and N_2O scope 2 emissions from the facility.

B.2 Purchased Steam or Hot Water and Chilled Water

Some agencies purchase steam or district heating for purposes like providing space heating in the buildings or providing process heating for industrial needs. Emissions associated with these sources are considered to be indirect. Agencies can also purchase, such as chilled water, for either cooling or refrigeration when they do not operate cooling compressors on-site at their facilities. Conceptually, purchased chilled water is similar to purchased heat or steam, with the primary difference being the process used to generate the chilled water.

B.2.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam, hot water and chilled water are primarily calculated from metered steam or hot water consumption, and metered chilled water consumption data and published emission factors. Table B-3 shows the minimum required methodologies and data sources for calculating scope 2 emissions from steam, hot water and chilled water use.

Table B-3: Purchased Steam or Hot Water and Chilled Water Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Calculation Methodology: Steam or Hot Water		
Steam or Hot Water	• Steam or hot water consumption (MMBtu)	• Annual Energy reporting • Purchasing records • Maintenance records

Emission Factor	• Standardized emission factors provided in Appendix D	• Standardized emission factors provided in Appendix B
Calculation Methodology: Chilled Water		
Chilled Water	• Cooling demand (MMBtu or Ton Hours) • Chiller type	• Annual Energy reporting • Purchasing records • Maintenance records
Emission Factor	• Standardized emission factors provided in Appendix D	• Calculated Emissions Factors

Calculation Steps

To calculate scope 2 emissions from chilled water and purchased steam or hot water:
1. Determine annual chilled water and steam/hot water use from all facilities within agency's organizational boundary;
2. Select the appropriate emission factors that apply to the steam and hot or chilled water used; and
3. Determine total annual emissions in metric tons of carbon dioxide equivalent

Step 1: Determine annual steam/hot water use from all facilities within agency's operational control

Steam/hot water/chilled water use data should be included for all facilities within an agencies organizational boundary.

Agencies should refer to [Federal Energy Management Guidance] for guidance on preferred sources for steam/hot water/chilled water data (i.e., metered readings or utility bills) and alternate methods for estimating steam/hot water use when metered data are not available.

Step 2: Select the appropriate emission factors that apply to the steam and hot water used

The steam and hot water emission factors represent the amount of GHGs emitted per unit of steam/hot water consumed. It is usually reported in units of kg of CO_2e per MMBtu of steam/hot water. See Appendix D.

The chilled water emission factor represents the amount of GHGs emitted per ton-hour of cooling. It is usually reported in units of kg of CO_2e per ton hour cooling and is determined by chiller type, if chiller type is unknown the user should use the emission factor for natural gas as a default.

Step 3: Determine total annual emissions in metric tons of carbon dioxide equivalent

To determine annual emissions, multiply annual steam/hot water use in MMBtu (Step 1) by the emission factors for CO_2, CH_4, and N_2O in kg of CO_2e per MMBtu (Step 2).

Equation B-6: Calculating Indirect Emissions from Steam/Hot Water Use

CO_2e **Emissions** (metric tons) =
Steam/Hot Water Use • Emission Factor ÷ 1,000
   (MMBtu)   (kg CO_2e/MMBtu)   (kg/metric ton)

To determine annual emissions from chilled water, multiply annual chilled water use in ton-hours cooling (Step 1) by the emission factors for CO_2, CH_4, and N_2O in kg of CO_2e per ton-hours cooling (Step 2).

Equation B-7: Calculating Indirect Emissions from Chilled Water Use

CO_2e **Emissions** (metric tons) =
Chilled Water Use   ●   Emission Factor   ÷   1,000
(ton-hours cooling) (kg CO_2e/ton-hours cooling) (kg/metric ton)

Example B-2: Purchased Steam or Hot Water and Chilled Water

After going through utility bills, an agency determines that it consumed 1,000 MMBtu of Steam and 2,000 MMBtu of Hot Water and 2,000 ton-hours of cooling (from an absorption chiller) for the year.

Step 1: Determine annual steam/hot water use and chill water from all facilities within agency's operational control

Steam = 1,000 MMBtu
Hot Water = 2,000 MMBtu
Chill Water = 2,000 ton hours of cooling

Step 2: Select the appropriate emission factors that apply to the steam/hot water and chiller water used

Steam = 86.85 kg CO_2e / MMBtu
Hot Water = 86.85 kg CO_2e / MMBtu
Chill Water = 0.8 kg CO_2e / ton-hours of cooling

Step 3: Determine total annual emissions in metric tons of CO_2e

Steam:
1,000 MMBtu • 86.85 kg CO_2e / MMBtu ÷ 1,000 = 86.85 metric tons of CO_2e
Hot Water:
2,000 MMBtu • 86.85 kg CO_2e / MMBtu ÷ 1,000 = 173.7 metric tons of CO_2e
Chilled Water:
2,000 ton-hours • 0.8 kg CO_2e / ton-hours ÷ 1,000 = 1.74 metric tons of CO_2e

Total emissions:
86.85 metric tons of CO_2e + 173.7 metric tons of CO_2e + 1.74 metric tons of CO_2e
= 262.29 metric tons of CO_2e

B.2.2 Detailed Calculation Methodology (User Calculated)

The detailed methodology for purchased steam, hot water, or chilled water uses the same equations as the minimum required method. However, to qualify under the detailed category, agencies would utilize the aforementioned method with plant and fuel specific emission factors to reflect site-specific efficiencies and conditions.

B.3 Electricity, Steam or Hot Water Purchases from a Combined Heat and Power Facility

Emissions from combined heat and power (CHP) facilities represent a special case for estimating scope 2 emissions. Because CHP simultaneously produces electricity and heat, attributing the total GHG emissions to each product stream would result in double counting and not provide proper credit for the inherent efficiency of cogeneration. Thus, when two or more parties receive the energy streams from CHP plants, GHG emissions must be determined and allocated separately for heat production and electricity production. Since the output from CHP results simultaneously in heat and electricity, determining what "share" of the total emissions is a result of electricity and heat by using a ratio based on the Btu content of heat and/or electricity relative to the CHP plant's total output.

Below are the minimum required and detailed approaches for calculating scope 2 emissions for heat or power purchases from a CHP facility. As this is a special case, it is recommended that agencies use detailed methods when at all possible given the overestimation of emissions possible with the minimum required methods.

B.3.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

The minimum required method presented requires only the quantity of electricity, steam, and/or hot water consumed from the local CHP, but it should be noted that the use of these simplified methods will likely result in overly conservative emission estimates. Though CHP calculation methodologies are normally site specific for simplification the minimum required method utilizes default values.

Table B-4: Combined Heat and Power Minimum Required Data Sources

Data Element	Preferred Sources
Minimum Required Method for Electricity Purchases	
Steam Or Hot Water	• See Purchased Electricity • See Purchased Steam or Hot Water

Minimum Required Methodology Calculations for CHP facilities

Because of the potential for overestimating scope 2 emissions, the minimum required methodology is not recommended in the case that agencies possess sufficient data for use of the detailed methods presented in this special case. However, in the absence of detailed data, the

minimum required approaches are built on the assumption that an agency is purchasing electricity and heat from standard less efficient systems rather than a CHP.

Minimum Required Method for Electricity Purchases

If purchased electricity is from a CHP facility, use the methodology in purchased electricity section to estimate scope 2 emissions from this source. This methodology assumes that an agency is purchasing electricity from the grid. Grid-average electricity may be produced less efficiently than electricity produced at a CHP facility, so this may result in an over-estimation of scope 2 emissions. Thus, use this methodology if the data from the CHP facility is unavailable.

Minimum Required Method for Heat Purchases

If an agency purchases steam or district heating from a CHP facility, use the methodology in steam and hot water section to calculate steam or hot water to estimate scope 2 emissions from this source. This methodology assumes that purchased steam or district heating is from a conventional boiler plant. Conventional boiler plants produce steam and heat less efficiently than CHP facilities, so this will result in an over-estimation of scope 2 emissions. Thus, only use this methodology if the data from the CHP facility is unavailable.

B.3.2 Detailed Methodology (User calculated)

Data Sources

The CHP calculation methodologies data requirements vary. The recommended detailed method requires only minimal utility purchase information and existing energy/emission datasets from the U.S. EPA eGRID program to calculate plant specific emissions. When a plant is not present in eGRID, the alternative method requires additional federal facility and utility CHP provider coordination to obtain the same energy, emissions, and allocation data.

Table B-5: Combined Heat and Power Detailed Data Sources

Data Element	Preferred Source
Detailed Calculation Methodology: CHP Facilities Present in eGRID	
CHP Identity	• Federal Facility Energy Manager
Electricity Use	• See Purchased Electricity
Steam or Hot Water	• See Purchased Steam or Hot Water and Chilled Water
Emission Factors	• eGRID Plant Data File
Plant Energy Input, CHP Adjustment, and Emissions	• eGRID Plant Data File
Detailed Calculation Methodology: CHP Facilities Not Present in eGRID	
Emissions based on fuel	• Fuel use data
Total electricity production from the CHP plant	• Based on generation and meter readings
Net heat production from the CHP	• Heat content values for steam at different temperature

plant	and pressure conditions
Emission Factor	• Appendix D

Alternative Methodology 1: CHP Facilities Present in eGRID

To calculate emissions from Heat and Power Purchases from a Combined Heat & Power Facility:

1. Determine annual CHP provided purchased electricity, steam, and/or hot water used from all facilities within agency's operational control;

2. Identify and select the appropriate emission factors that apply to the CHP electricity purchased;

3. Identify, calculate, and select the appropriate emission factors that apply to the steam purchased;

4. Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased; and

5. Calculate the total annual emissions in metric tons of greenhouse gases.

6. Determine the total annual emissions in metric tons of carbon dioxide equivalent.

Step 1: Determine annual CHP provided purchased electricity, steam, and/or hot water use from all facilities within agency's operational control

Electricity, steam, and/or hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the Guidance. This should align with the agency's annual energy consumption reporting to the DOE. Agencies should refer to [Federal Energy Management Guidance[33]] for guidance on preferred sources for electricity use data (i.e., metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available.

Step 2: Identify and select the appropriate emission factors that apply to the CHP electricity purchased

The electricity emission factor represents the amount of GHGs emitted per unit of CHP electricity consumed. It is usually reported in units of pounds of GHG per MWh or GWh.

As with standard grid provided electricity, eGRID emission factors are used to provide a consistent, verifiable basis for emissions calculations. Given the direct usage of CHP electricity, this special case requires that use of CHP specific plant emission factors. Given the periodic eGRID updates, agencies should use the eGRID CHP plant emission rates corresponding to the year of their inventory activity data. As with standard grid provided electricity, agencies are not expected to retroactively update their inventories with new eGRID factors once the inventory has been submitted to CEQ.

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[33] http://www1.eere.energy.gov/femp/regulations/guidance.html.

Go to the eGRID program web site and download the most current version's "eGRID Plant, Boiler, and Generator Data Files." Find the identified CHP in the Plant File using the state and county data elements to simplify the search. Once identified, the CHP specific emission factors are identified in the applicable columns as:

- Plant Annual CO_2 Output Emission Rate (PLCO$_2$RTA)

- Plant Annual CH_4 Output Emission Rate (PLCH$_4$RTA)

- Plant Annual N_2O Output Emission Rate (PLN$_2$ORTA)

Step 3: Identify, calculate, and select the appropriate emission factors that apply to the steam purchased

The steam emission factor represents the amount of GHGs emitted per unit of CHP delivered steam consumed. These emission factors would typically be reported in units of pounds of GHG per MMBTU.

Using the downloaded eGRID Plant file and the identified CHP from the purchased electricity, the steam emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP specific datasets include:

- Plant Unadjusted Annual CO_2 Emissions (UNCO$_2$)

- Plant Unadjusted Annual CH_4 Emissions (UNCH$_4$)

- Plant Unadjusted Annual N_2O Emissions (UNN$_2$O)

- Plant Annual CO_2 Emissions (PLCO$_2$AN)

- Plant Annual CH_4 Emissions (PLCH$_4$AN)

- Plant Annual N_2O Emissions (PLN$_2$OAN)

- CHP Plant Useful Thermal Output (USETHRMO)

This steam emission factor calculation methodology is elaborated in Equation B-8.

Equation B-8: eGRID CHP Plant Steam Emission Factor Calculation

eGRID CHP Steam Emission Factor [lbs CO_2 / MMBTU] =

$$[(UNCO_2 - PLCO_2AN) \bullet STLC] \div [(USETHRMO \bullet SP) \bullet DL]$$

where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [Short Tons CO_2].

$PLCO_2AN$ = Plant Annual CO_2 Emissions [Short Tons CO_2].

STLC = Short Ton to Pounds (lbs.) Conversion (2000) [lbs / Short Ton].

USETHRMO = CHP Plant Useful Thermal Output [MMBTUs].

SP = Steam Production Efficiency (75%).

DL = Distribution Loss (10%).

The CH_4 and N_2O emission factors are likewise derived by substituting $UNCH_4$ or UNN_2O for $UNCO_2$ and by substituting $PLCH_4AN$ or PLN_2OAN for $PLCO_2AN$.

Step 4: Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased

The hot water emission factor represents the amount of GHGs emitted per unit of CHP delivered hot water consumed. These emission factors would typically be reported in units of pounds of GHG per MMBTU.

As with Step 3, the steam emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP specific datasets include:

- Plant Unadjusted Annual CO_2 Emissions ($UNCO_2$)
- Plant Unadjusted Annual CH_4 Emissions ($UNCH_4$)
- Plant Unadjusted Annual N_2O Emissions (UNN_2O)
- Plant Annual CO_2 Emissions ($PLCO_2AN$)
- Plant Annual CH_4 Emissions ($PLCH_4AN$)
- Plant Annual N_2O Emissions (PLN_2OAN)
- CHP Plant Useful Thermal Output (USETHRMO)

This hot water emission factor calculation methodology is elaborated in Equation B-9.

Equation B-9: eGRID CHP Plant Hot Water Emission Factor Calculation

eGRID CHP Hot Water Emission Factor [lbs CO_2 / MMBTU] =

$$[(UNCO_2 - PLCO_2AN) \bullet STLC] \div [USETHRMO \bullet DL]$$

where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [Short Tons CO_2]

$PLCO_2AN$ = Plant Annual CO_2 Emissions [Short Tons CO_2]

STLC = Short Ton to Pounds (lbs.) Conversion (2000) [lbs / Short Ton]

USETHRMO = CHP Plant Useful Thermal Output [MMBTUs]

DL = Distribution Loss (10%)

Similar to Step 3, the CH_4 and N_2O emission factors are likewise derived by substituting $UNCH_4$ or UNN_2O for $UNCO_2$ and by substituting $PLCH_4AN$ or PLN_2OAN for $PLCO_2AN$. However, STLC is omitted due to a change from reporting in short tons to lbs.

Step 5: Determine total annual emissions in metric tons of greenhouse gases

To determine annual emissions, multiply annual electricity, steam, and/or hot water use (Step 1) by the respective emission factors for CO_2, CH_4, and N_2O in pounds per MWh (Step 2) or MMBTU (Step 3 and 4).

Equation B-10: Calculating Indirect Emissions from Electricity Use

CO_2 Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs CO_2/MWh) ÷ 2,204.62 (lbs/metric ton)
CH_4 Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs CH_4/MWh) ÷ 2,204.62 (lbs/metric ton)
N_2O Emissions (metric tons) =   Electricity Use (MWh) • Emission Factor (lbs N_2O/MWh) ÷ 2,204.62 (lbs/metric ton)

Equation B-11: Calculating Indirect Emissions from Purchased Steam Use

CO_2 Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/metric ton)
CH_4 Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/metric ton)
N_2O Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/metric ton)

Equation B-12: Calculating Indirect Emissions from Purchased Hot Water Use

CO_2 Emissions (metric tons) =   Hot Water Use (MMBTU) • Emission Factor (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/metric ton)
CH_4 Emissions (metric tons) =   Hot Water Use (MMBTU) • Emission Factor (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/metric ton)
N_2O Emissions (metric tons) =   Hot Water Use (MMBTU) • Emission Factor (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/metric ton)

Step 6: Determine total annual emissions in metric tons of CO_2e

The final step is to convert CH_4 and N_2O into units of CO_2e, multiply total emissions of each gas (in metric tons) by its IPCC GWP factor provided in Appendix B. Then, sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-13: Converting to CO_2e and Determining Total Emissions

CO_2 Emissions (metric tons CO_2e) = CO_2 Emissions (metric tons) • 1 (GWP)
CH_4 Emissions (metric tons CO_2e) = CH_4 Emissions (metric tons) • 21 (GWP)
N_2O Emissions (metric tons CO_2e) = N_2O Emissions (metric tons) • 310 (GWP)
Total Emissions (metric tons CO_2e) = $CO_2 + CH_4 + N_2O$ (metric tons CO_2e)

Example B-3: Heat and Power Purchases from a Combined Heat & Power Facility

As a notional example, a U.S. Navy facility in New York State directly purchases electric, steam, and hot water from a CHP facility named Brooklyn Navy Yard Cogeneration. This plant is owned and operated by Olympus Power LLC. For the purposes of this example, the plant is outside of the U.S. Navy's operational control, the emissions associated with the electricity, steam and hot water used would be calculated and reported as scope 2 emissions.

Step 1: Access U.S. Navy Facility Report Energy Use

U.S. Navy Purchases from NTC/MCRD Energy CHP	
Electricity (MWh)	750
Steam (MMBTU)	300
Hot Water (MMBTU)	150

Step 2: Locate NTC/MCRD Energy CHP Plant and its Electricity Emission Factors in eGRID Plant File
CO_2 Emission Factor [lbs CO_2 / MWH] = PLCO2RTA = 1230.9
CH_4 Emission Factor [lbs CH_4 / GWH] = PLCH4RTA = 23.8
N_2O Emission Factor [lbs N_2O / GWH] = PLN2ORTA = 2.3833

Step 3: Calculate CHP Plant Steam Emission Factors from eGRID
CO_2 Emission Factor [lbs CO_2 / MMBTU] =
  [(UNCO$_2$ - PLCO$_2$AN) ● STLC] ÷ [(USETHRMO ● SP) ● DL] =
  [(1,095,258.8 - 1,093,667.6) ● 2000] ÷ [(11,765.4 ● 0.75) ● 0.90] =
  [1,591.2 ● 2000] ÷ [(8,824.1) ● 0.90] =
  [3,182,400] ÷ [7941.7] =
  400.7
CH_4 Emission Factor [lbs CH_4 / MMBTU] =
  [(UNCH$_4$ - PL CH$_4$AN)] ÷ [(USETHRMO ● SP) ● DL] =
  [(42,413.1 - 42,351.5)] ÷ [(11,765.4 ● 0.75) ● 0.90] =
  [61.6] ÷ [(8,824.1) ● 0.90] =
  [61.6] ÷ [7941.7] =
  0.00776
N_2O Emission Factor [lbs N_2O / MMBTU] =
  [(UNN$_2$O - PLN$_2$OAN)] ÷ [(USETHRMO ● SP) ● DL] =
  [(4241.3 - 4235.1)] ÷ [(11765.4 ● 0.75) ● 0.90] =
  [6.2] ÷ [(8,824.1) ● 0.90] =
  [6.2] ÷ [7941.7] =
  0.000781

Step 4: Locate CHP Plant and Electricity Emission Factors in eGRID

CO_2 Emission Factor [lbs CO_2 / MMBTU] =
 [(UNCO$_2$ - PLCO$_2$AN) ● STLC] ÷ [USETHRMO ● DL] =
 [(1,095,258.8 - 1,093,667.6) ● 2000] ÷ [11,765.4 ● 0.90] =
 [1,591.2 ● 2000] ÷ [11,765.4 ● 0.90] =
 [3,182,400] ÷ [10,558.9] =
 301.4

CH_4 Emission Factor [lbs CH_4 / MMBTU] =
 [(UNCH$_4$ - PL CH$_4$AN)] ÷ [USETHRMO ● DL] =
 [(42,413.1 - 42,351.5)] ÷ [11,765.4 ● 0.90] =
 [61.6] ÷ [11,765.4 ● 0.90] =
 [61.6] ÷ [10,558.9] =
 0.00583

 N_2O Emission Factor [lbs N_2O / MMBTU] =
 [(UNN$_2$O - PLN$_2$OAN)] ÷ [USETHRMO ● DL] =
 [(4241.3 - 4235.1)] ÷ [11,765.4 ● 0.90] =
 [6.2] ÷ [11,765.4 ● 0.90] =
 [6.2] ÷ [10,558.9] =
 0.000587

Step 5: Calculate Annual Emissions in Metric Tons of Greenhouse Gases

Electric CO_2 Emissions (metric tons) =
 Electricity Use (MWh) • Emission Factor (lbs CO_2/MWh) ÷ 2,204.62 (lbs/MT) =
 750 (MWh) • 1230.9 (lbs CO_2/MWh) ÷ 2,204.62 (lbs/metric ton) =
 418.7

Electric CH_4 Emissions (metric tons) =
 Electricity Use (MWh) • Emission Factor (lbs CH_4/MWh) ÷ 2,204.62 (lbs/ MT) =
 750 (MWh) • 23.8 (lbs CH_4/MWh) ÷ 2,204.62 (lbs/metric ton) =
 8.1

Electric N_2O Emissions (metric tons) =
 Electricity Use (MWh) • Emission Factor (lbs N_2O/MWh) ÷ 2,204.62 (lbs/ MT) =
 750 (MWh) • 2.3833 (lbs N_2O/MWh) ÷ 2,204.62 (lbs/metric ton) =
 0.809

Steam CO_2 Emissions (metric tons) =
 Steam Use (MMBTU) • Emission Factor (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/MT) =
 300 (MMBTU) • 400.7 (lbs CO_2/MMBTU) ÷ 2,204.62 (lbs/metric ton) =
 54.5

Steam CH_4 Emissions (metric tons) =
 Steam Use (MMBTU) • Emission Factor (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
 300 (MMBTU) • 0.00776 (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/metric ton) =
 0.00106

Steam N_2O Emissions (metric tons) =
 Steam Use (MMBTU) • Emission Factor (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
 300 (MWh) • 0.000781 (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/metric ton) =
 0.000106

Hot Water CO_2 Emissions (metric tons) =
  Hot Water Use (MMBTU) • Emission Factor (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/MT) =
  150 (MMBTU) • 301.4 (lbs CO_2/MMBTU) ÷ 2,204.62 (lbs/metric ton) =
  20.5
Hot Water CH_4 Emissions (metric tons) =
  Hot Water Use (MMBTU) • Emission Factor (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
  150 (MMBTU) • 0.00583 (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/metric ton) =
  0.000397
Hot Water N_2O Emissions (metric tons) =
  Hot Water Use (MMBTU) • Emission Factor (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
  150 (MWh) • 0.000587 (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/metric ton) =
  0.0000399

Step 6: Calculate Annual Emissions in Metric Tons of Greenhouse Gases (e.g., Steam)
Converting to CO_2eand Determining Total Emissions
CO_2 Emissions (metric tons CO2e) =
  CO_2 Emissions (metric tons) • 1 (GWP) =
  54.5 (metric tons) • 1 (GWP) =
  54.5
CH_4 Emissions (metric tons CO2e) =
  CH_4 Emissions (metric tons) • 21 (GWP) =
  0.00106 (metric tons) • 21 (GWP) =
  0.0223
N_2O Emissions (metric tons CO2e) =
  N_2O Emissions (metric tons) • 310 (GWP) =
  0.000106 (metric tons) • 310 (GWP) =
  0.0329
Total Emissions (metric tons CO_2e) =
  CO_2 + CH_4 + N_2O (metric tons CO_2e) =
  54.5 + 0.0223 + 0.0329 (metric tons CO_2e) =
  54.6

Alternative Methodology 2: CHP Facilities Not Present in eGRID[34]

The process for estimating scope 2 emissions from the heat and power product streams produced at a CHP facility involves the following four steps:

1. Obtain total emissions, power and heat generation information from CHP facility;

2. Determine emissions attributable to net heat production and electricity production;

3. Calculate emissions attributable to the agency's portion of heat and electricity consumed; and

4. Convert to units of CO_2e and determine total emissions.

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[34] Climate Leaders *Indirect Emissions from Purchases/Sales of Electricity and Steam* June 2008.

Step 1: Obtain emissions and power and heat information from the CHP facility

Obtain the following information from the CHP plant owner or operator to estimate scope 2 GHG emissions:

- Total emissions of CO_2, CH_4, and N_2O from the CHP facility, based on fuel input information;

- Total electricity production from the CHP plant, based on generation meter readings; and

- Net heat production from the CHP plant.

Net heat production refers to the useful heat that is produced in CHP, minus whatever heat returns to the boiler as steam condensate, as shown in the equation below.

Equation B-14: Calculating Net Heat Production

Net Heat Production (MMBtu) = Heat of Steam Export (MMBtu) - Heat of Return Condensate (MMBtu)

Step 2: Determine emissions attributable to net heat production and electricity production for the CHP plant

The most consistent approach for allocating GHG emissions in CHP applications is the efficiency method, which allocates emissions of CHP plants between electric and thermal outputs on the basis of the energy input used to produce the separate steam and electricity products. To use this method, obtain the following information:

- The total emissions from the CHP plant;

- The total steam (or heat) and electricity production; and

- The steam (or heat) and electricity efficiency of the facility.

Use the following steps to determine the share of emissions attributable to steam (or heat) and electricity production.

Determine the Total Scope 1 Emissions from the CHP System

Calculate total scope 1 GHG emissions using the methods described in Appendix A.

Determine the Total Steam and Electricity Output for the CHP System

To determine the total energy output of the CHP plant attributable to steam production, use published tables that provide heat content values for steam at different temperature and pressure conditions [for example, the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam published by the International Association for the Properties of Water and

Steam (IAPWS)]. Energy content values multiplied by the quantity of steam produced at the temperature and pressure of the CHP plant yield energy output values in units of MMBtu.

Alternatively, determine net heat (or steam) production (in MMBtu) by subtracting the heat of return condensate (MMBtu) from the heat of steam export (MMBtu). To convert total electricity production from MWh to MMBtu, multiply by 3.412 MMBtu/MWh.

Determine the Efficiencies of Steam and Electricity Production

Identify steam (or heat) and electricity production efficiencies. If actual efficiencies of the CHP plant are not known, use a default value of 80 percent for steam and a default value of 35 percent for electricity. The use of default efficiency values may, in some cases, violate the energy balance constraints of some CHP systems. However, total emissions will still be allocated between the energy outputs. If the constraints are not satisfied, the efficiencies of the steam and electricity can be modified until constraints are met.

Determine the Fraction of Total Emissions Allocated to Steam and Electricity Production

Allocate the emissions from the CHP plant to the steam (or heat) and electricity product streams by using the equation below.

Equation B-15: Allocating CHP Emissions to Steam and Electricity

Step 1: $E_H = \dfrac{H \cdot e_P \cdot E_T}{P \cdot e_H + H \cdot e_P}$

Step 2: EP = ET – EH

where:
EH = Emissions allocated to steam production.
H = Total steam (or heat) output (MMBtu).
eH = Efficiency of steam (or heat) production.
P = Total electricity output (MMBtu).
eP = Efficiency of electricity generation.
ET = Total direct emissions of the CHP system.
EP = Emissions allocated to electricity production.

Step 3: Calculate emissions attributable to the agency's portion of heat and electricity consumed

After determining total emissions attributable to heat and electricity production, calculate your portion of heat or electricity consumed, and thus your indirect GHG emissions associated with heat or electricity use. First, obtain electricity and heat consumption information, then use the equations below to calculate the agency's share of emissions, as appropriate.

Equation B-16: Calculating Indirect Emissions Attributable To Electricity Consumption

Indirect Emissions Attributable to Electricity Consumption (*metric tons*) =

Total CHP Emissions Attributable to Electricity Production (*metric tons)* • [Your Electricity

Consumption (kWh) ÷ Total CHP Electricity Production (kWh)]

Equation B-17: Calculating Indirect Emissions Attributable To Heat (or Steam) Consumption

Indirect Emissions Attributable to Heat Consumption (*metric tons*) =

Total CHP Emissions Attributable to Heat Production *(metric tons)* • (Your Heat Consumption *(MMBtu)* ÷ CHP Net Heat Production *(MMBtu)*)

Step 4: Convert to units of CO_2 equivalent and determine total emissions

Finally, use the IPCC GWP factors provided below to convert CH_4 and N_2O emissions to units of CO_2e. Then sum the emissions of all three gases to determine an agency's total emissions from combined heat and power.

Equation B-18: Converting to CO_2e and Determining Total Emissions

CO_2 Emissions = CO_2 Emissions • 1(metric tons CO_2e) (metric tons) (GWP)

CH_4 Emissions = CH_4 Emissions • 21(metric tons CO_2e) (metric tons) (GWP)

N_2O Emissions = N_2O Emissions • 310(metric tons CO_2e) (metric tons) (GWP)

Total Emissions = CO_2 + CH_4 + N_2O(metric tons CO_2e) (metric tons CO_2e)

B.4 Steam Purchases from a MSW Waste-to-Energy Facility

Description

GHG emissions from municipal solid waste (MSW) fired waste-to-energy (WTE) facilities represent special case for estimating scope 2 emissions. WTE plants use MSW as a primary fuel to generate steam via this dual use energy recovery and waste management application. Their MSW fuel is comprised of both renewable biomass (e.g., wood, paper, and food) and nonrenewable materials (e.g., plastics and tires). Several of these WTE facilities were built in close proximity to federal facilities to take mutual advantage of a long-term steam purchase agreements and to provide a significant portion of the federal facilities thermal energy requirements. While MSW fueled CHPs are accounted for in the U.S. EPA eGRID program, WTE plants producing only thermal energy are not subject to or participants in the program. As such, this section provides both a site specific and a simplified approach for calculating the GHG emissions associated with the steam purchases from MSW fueled WTE plants. Below are the minimum required and detailed approaches for calculating scope 2 GHG and biogenic CO_2 emissions from MSW fueled WTE generated steam purchases.

B.4.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam, generated by a MSW fired WTE plant can be calculated from the metered delivered steam and the default or plant-specific emission factors. Below are the recommended and alternate activity data and emission factors for calculating scope 2 emissions from MSW fueled steam purchases.

Table B-6: Steam Purchases from Municipal Solid Waste Fired, Waste-to-Energy Plants Minimum Data Sources

Data Element	Preferred Source	Alternate Source
Calculation Methodology for MSW WTE Facilities		
Purchased Steam	• See Purchased Steam	• See Purchased Steam
Emission Factors	• eGRID Derived Default	• MSW WTE Plant Provided

Calculation Steps

If site-specific MSW WTE plant emission factors are not available, agencies may use an alternative methodology that utilizes default emission factors derived from similar MSW fired WTE plants captured via the eGRID program (i.e., plants that generate electricity, not steam). The steps to calculate scope 2 emissions from MSW fueled, WTE delivered steam are identical to those used for the detailed method, except for Step 2. These steps are to:

1. Determine annual delivered steam purchased for use by all facilities within agency's operational control;

2. **Utilize the most recent eGRID Derived Emission Factors that apply to the delivered steam ;**

3. Determine the total annual emissions in metric tons for each GHG; and

4. Determine total annual emissions in metric tons of CO_2e.

Indicent Emissions Factor Defaults from MSW WTE Purchased Steam Use	
CO_2 Emissions (lbs CO_2/MMBTU)	350.5 (lbs CO_2/MMBTU)
CH_4 Emissions (lbs CH_4/MMBTU)	0.1292 (lbs CH_4/MMBTU)
N_2O Emissions (lbs N_2O /MMBTU)	0.0172 (lbs N_2O /MMBTU)
Biogenic CO_2 Emissions (lbs CO_2/MMBTU)	385.6 (lbs CO_2/MMBTU)

These default emission factors were derived from a sample of similar MSW fueled WTE plant found in the eGRID2007 Version 1.1 Plant File (Year 2005 Data). These 49 plants were selected based upon their primary fuel being MSW and their electric only productions (i.e., no CHPs with apportioned data inputs). Using a similar approach to that outlined in Section B-3 "Alternative

Calculation Methodology for CHP Facilities Not Present in eGRID" approach, these plants' delivered steam emission factors were calculated using the following extracted eGRID data elements:

- Plant annual heat input (MMBTU) (PLHTIAN)

- Plant unadjusted annual CO_2 emissions (tons) ($UNCO_2$)

- Plant unadjusted annual CH_4 emissions (lbs) ($UNCH_4$)

- Plant unadjusted annual N_2O emissions (lbs) (UNN_2O)

- Plant total nonrenewables generation percent (resource mix) (%) (PLTNPR)

- Plant total renewables generation percent (resource mix) (%) (PLTRPR)

Each plant's annual heat input (MMBTU) was converted to delivered steam using standard assumptions for:

- External Boiler Efficiency (80%)[35]

- Steam Conversion Efficiency (75%)[36]

- Distribution Loss (10%)[37]

Equation B-20: eGRID MSW WTE Delivered Steam

eGRID MSW WTE Delivered Steam [MMBTU] =
    PLHTIAN ● BE ● SP ● DL

where:
 PLHTIAN = Plant annual heat input [MMBTU].
 BE = Steam Production Efficiency (80%).
 SP = Steam Production Efficiency (75%).
 DL = Distribution Loss (10%).

The eGRID Plant unadjusted annual CO_2 emissions (tons), Plant unadjusted annual CH_4 emissions (lbs) ($UNCH_4$), and Plant unadjusted annual N_2O emissions (lbs) (UNN_2O) quantities have all then been used numerator and the delivered steam as denominators to develop plant specific emission factors for CO_2, CH_4, and N_2O.

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[35] U.S. DOE Energy Efficiency and Renewable Energy (EERE), Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See at:
http://www1.eere.energy.gov/industry/program_areas/footprints.html.
[36] eGRID2007 Technical Support Document, U.S. EPA. See at:
http://www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.
[37] U.S. DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (March 2006) p. 154-156. See at:
http://www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

Equation B-21: eGRID MSW WTE Delivered Steam

eGRID MSW WTE Delivered Steam Emission Factor [lbs CO_2 / MMBTU] =

$(UNCO_2 \bullet STLC) \div DS = UNCO_2 \text{ (lbs)} \div DS \text{ (MMBTU)}$

where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [Short Tons CO_2].

STLC = Short Ton to Pounds (lbs.) Conversion (2000) [lbs/Short Ton].

DS = Delivered Steam.

With the exception of the lbs/ton conversion, the emission factors for CH_4 and N_2O were similarly calculated. However, as eGRID eliminates all biogenic CO_2 from its emission factors, the biogenic CO_2 emission factor was generated by back calculating each respective Plant's total CO_2 emissions and, then, breaking out the biogenic CO_2 emission portion using Equation B-4c.

Equation B-22: eGRID MSW WTE Biogenic CO_2 Factor

eGRID MSW WTE Delivered Steam Emission Factor [lbs CO_2 (Biogenic) / MMBTU] =

$[(UNCO_2 \bullet STLC) \bullet (PLTRPR / PLTNPR)] \div DS$

where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [Short Tons CO_2].

STLC = Short Ton to Pounds (lbs.) Conversion (2000) [lbs / Short Ton].

PLTNPR = Plant total nonrenewables generation percent (resource mix) (%).

PLTRPR = Plant total renewables generation percent (resource mix) (%).

DS = Delivered Steam.

These emission factors were calculated for all 49 of the eGRID MSW WTE plants. The median plant value for anthropogenic CO_2 was identified, and this plant's derived values were used as the default emission factors. The detailed datasheet used to calculate these values can be obtained by contacting FEMP.

B.4.2 Detailed Methodology (User Calculated)

There is only one alternative detailed Calculation Methodology for MSW WTE Steam Purchases, as shown below.

Calculation Steps

To calculate scope 2 emissions from MSW fueled, WTE purchased steam:

1. Determine annual delivered steam purchased for use by all facilities within agency's operational control;

2. Obtain the provider plant's most recent emission factors that apply to the delivered steam;

3. Determine the total annual emissions in metric tons for each GHG; and

4. Determine total annual emissions in metric tons of CO_2e.

Step 1: Determine annual delivered steam purchased for use by all facilities within agency's operational control

Purchased steam and hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2of the Guidance. This should align with the agency's annual energy consumption reporting to the DOE and maintain consistency with the data used for calculations as outlined in both sections B-2 and B-3.

Step 2: Obtain the provider plant's most recent emission factors that apply to the delivered steam

Based upon preliminary federal GHG inventory experience, local MSW fueled, WTE thermal plant operators already calculate and maintain records on total fuel input, GHG emission factors useful heat production, and delivered steam and hot water emission factors. Given the recent release and stringent requirements of the U.S. EPA's Mandatory Reporting Rule, it is anticipated that these records and calculations will become even more robust and available by the end of calendar year 2010 for all covered facilities. As such, the recommended source of current emission factors is your facility's local facility's WTE account manager and/or the facility's environmental manager. When obtaining these factors, it is imperative that your Agency's representative specifically request non-offset adjusted factors as many providers may already have incorporated petroleum fuel offset methodologies into their final consumer emission factors. If they have not calculated these factors, it is possible to work with your provider and utilize the "Alternative Calculation Methodology for CHP Facilities Not Present in eGRID" detailed in Section B-3 by specifying a 100 percent allocation to steam production.

If obtaining (or developing) site-specific emission factors is not possible, utilize the default emission factors outlined below in the "Alternative Methodology for MSW WTE Facilities" approach.

Step 3: Determine total annual emissions in metric tons for each GHG

To determine annual emissions, multiply annual purchased steam in MMBTU (Step 1) by the emission factors for CO_2, CH_4, and N_2O in pounds per MMBTU of delivered steam (Step 2). Then, divide this product by 2,204.62 to covert to metric tons.

Equation B-23: Calculating Indirect Emissions from Purchased Steam Use

CO_2 Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs CO_2/MMBTU) ÷ 2,204.62 (lbs/metric ton)
CH_4 Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs CH_4/MMBTU) ÷ 2,204.62 (lbs/metric ton)
N_2O Emissions (metric tons) =   Steam Use (MMBTU) • Emission Factor (lbs N_2O /MMBTU) ÷ 2,204.62 (lbs/metric ton)

Biogenic CO_2 Emissions (metric tons) =
Steam Use (MMBTU) • Emission Factor (lbs CO_2/MMBTU) ÷ 2,204.62 (lbs/metric ton)

Step 4: Determine total annual emissions in metric tons of CO_2e

The final step is to convert the anthropogenic CO_2, CH_4 and N_2O into units of CO_2e by multiplying the total emissions of each gas (in metric tons) by its IPCC GWP factor provided in Appendix B. Then, sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-24: Converting to CO_2e and Determining Total Emissions

CO_2 Emissions (metric tons CO_2e) =
CO_2 Emissions (metric tons) • 1 (GWP)

CH_4 Emissions (metric tons CO_2e) =
CH_4 Emissions (metric tons) • 21 (GWP)

N_2O Emissions (metric tons CO_2e) =
N_2O Emissions (metric tons) • 310 (GWP)

Total Emissions (metric tons CO_2e) =
CO_2 + CH_4 + N_2O (metric tons CO_2e)

Biogenic CO_2 emissions resulting from MSW WTE purchased steam should not to be added to scope 2 emissions subtotals. These emission quantities are added to a separate biogenic CO_2 emissions subtotal external to the scope 1, 2, and 3 emissions.

Example B-4: Steam Purchases from Municipal Solid Waste Fired, Waste-to-Energy Plant

A NASA facility in Hampton, Virginia purchases steam from a local MSW fueled WTE plant close to its facility to help meet its thermal energy needs.

Step 1: Determine annual delivered steam purchased
The Center's Energy Manager maintains records and bills paid for the purchased steam, which is used to generate part of facilities /energy report. For this fiscal year, the total purchased steam delivered and used at the Center 1,500 MMBTUs.

Step 2: Obtain the provider's most recent emission factors
After a request is submitted to the MSW WTE steam plant's account manager, the NASA Center is provided with the following Emission Factors.

Site Specific MSW WTE Purchased Steam Emissions Factor	
CO_2 Emission Factor	320.5 (lbs CO_2/MMBTU)
CH_4 Emission Factor	0.1475 (lbs CH_4/MMBTU)
N_2O Emission Factor	0.0165 (lbs N_2O /MMBTU)
Biogenic CO_2 Emission Factor	390.5 (lbs CO_2/MMBTU)

Step 3: Determine total annual emissions for each GHG
Equation B-4a: Calculating Indirect Emissions from Purchased Steam Use
Purchased Steam CO_2 Emissions (MT) =
   1,500 (MMBTU) ● 320.5 (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/MT) =
   218.1 (MT CO_2)
Purchased Steam CH_4 Emissions (MT) =
   1,500 (MMBTU) ● 0.1475 (lbs CH_4/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
   0.1004 (MT CH_4)
Purchased Steam N_2O Emissions (MT) =
   1,500 (MMBTU) ● 0.0165 (lbs N_2O/ MMBTU) ÷ 2,204.62 (lbs/ MT) =
   0.01123 (MT N_2O)
Purchased Steam Biogenic CO_2 Emissions (MT) =
   1,500 (MMBTU) ● 390.5 (lbs CO_2/ MMBTU) ÷ 2,204.62 (lbs/MT) =
   265.7 (MT Biogenic CO_2)

Step 4: Determine total annual emissions in MT CO_2e
Equation B-4b: Converting to CO_2e and Determining Total Emissions
Purchased Steam CO_2 Emissions (MT CO_2e) =
   218.1 (MT CO_2e) ● 1 (GWP) =
   218.1 (MT CO_2e)
Purchased Steam CH_4 Emissions (MT CO_2e) =
   0.1004 (MT CH_4) ● 21 (GWP) =
   2.108 (MT CO_2e)
Purchased Steam N_2O Emissions (MT CO_2e) =
   0.01123 (MT N_2O) ● 310 (GWP) =
   3.481 (MT CO_2e)
Purchased Steam Total Emissions (MT CO_2e) =
   218.1 + 2.108 + 3.481 (MT CO_2e) =
   223.7 (MT CO_2e)

Distribution Losses

When an agency purchases steam and hot water and, then, transports it through a distribution system that it owns or controls, report the emissions associated with distribution losses under scope 2. End consumers (e.g., non-agency tenants) of the purchased steam, do not report indirect emissions associated with distribution system losses in scope 2 because they do not own or control the distribution system's operation, where the thermal energy is lost to the ambient environment. To estimate these distribution emissions, use the approach and methods outlined in Appendix D Scope 3 Emissions.

B.5 Quantifying Emission Reductions from RECs

B.5.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)

Calculation Steps

To calculate scope 2 emission reductions from RECs:

Step 1: Determine emissions normally emitted

Use methodologies above to establish a "baseline" or actual quantity of emissions that would be emitted in the absence of the renewable energy purchases.

Step 2: Estimating Emission Reductions

The procedure used to estimate emission reductions are shown below. Initial estimates of the reductions can be made using assumptions for the amount of renewable energy purchased and the location of the renewable energy facility.

Equation B-25: Calculating Emission Reductions

Emission reduction$_{i,sr}$ = RE$_{sr}$ • ERate_avoided$_{i,sr}$

where:
- Emission reduction$_{i,sr}$ is the quantity (lbs) of avoided greenhouse gas of type *i* in each subregion *sr*.
- RE$_{sr}$ is the quantity of renewable energy purposefully purchased from each subregion *sr* as distinct from the agency's electricity supplier's system mix of energy resources.
- ERate_avoided$_{i,sr}$ is the emission factor for each greenhouse gas of type *i* (e.g., lb CO_2/MWh, lb CH_4/MWh, lb N_2O/MWh) for each subregion *sr* where the renewable energy generators are located.

These emission reductions must then be summed for each GHG and for each subregion in which the renewable energy generators are located.

Equation B-26: Sum Emission Reductions by GHG and Subregion

Inventory adjustment = $\sum$Baseline emissions$_{i,sr}$ - $\sum$Emission reduction$_{i,sr}$

where:
- Inventory adjustment is the number reported as scope 2 emissions.
- $\sum$Baseline emissions$_{i,sr}$ is the summation of baseline emissions (from Equation 1).
- $\sum$Emission reduction$_{i,sr}$ is the summation of emission reductions (from Equation 2).

For renewable energy purchased from U.S. generating facilities, the default emission rate for ERatebaseline$_{i,sr}$ is the eGRID non-baseload emission rate for the eGRID subregion(s) in which the renewable electricity was generated. The most current eGRID emission rates published should be used at the time the inventory adjustment is calculated.

For renewable energy purchased from international renewable facilities, the emission rate used for ERatebaseline$_{i,sr}$ should be a non-baseload emission rate (this is a marginal emission rate), if available, for the country or region of origin. Otherwise, a system average emission rate should be used. Regional emission rates are preferable if available, but national average rates can also be used for non-U.S. locations. Only international Federal facilities should purchase international renewable energy.

Agencies should use the non-baseload emission rate for the eGRID subregion(s) in which the renewable energy was generated.[38] The location of the renewable energy generator(s) from which the renewable energy is sourced should be requested from the renewable energy supplier. This information may not be available from the agency's supplier until after the year has ended. If the generators are located in multiple subregions, the calculation to determine emission reductions should be repeated for each subregion, using the amount of renewable energy purchased from each subregion.

Step 3: Calculating Actual Reductions

The quantification of actual emission reductions occurs after the renewable energy purchase has been completed and monitored.

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[38] The reason for using the non-baseload emission factor is that non-baseload generation is most likely to be displaced by renewable energy generation, while baseload generation would generally be unaffected. The exclusion of baseload generation from the calculation of emission rates is a widely accepted approach internationally.

Appendix C – Calculating Scope 3 Emissions

Scope 3 emissions are those that are a consequence of agency activities, but come from sources not controlled by the agency. An agency's scope 3 emissions are the scope 1 or scope 2 emissions of another agency or organization. Refer to Chapter 2 of the Guidance for further information on organizational boundaries.

Table C-1 outlines which scope 3 emission categories agencies are required to report, and which categories are optional.

Table C-1: Scope 3 Emissions Categories

Required Scope 3 Emission Categories
Employee business travel (Air travel)
Contracted disposal of waste generated in operations (solid waste and wastewater treatment)
Transmission and distribution losses
Optional Scope 3 Emissions Categories
Employee business travel (Ground travel)
Employee commuter travel

C.1 Employee Business Travel: Air Travel

Description

Business air travel includes transportation to move Federal employees to accomplish business-related activities in aircraft owned or operated by third parties. Scope 3 emissions from business air travel include those from the combustion of fuels (e.g., the fuel consumed by an aircraft), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (e.g., the emissions associated with aircraft manufacturing).

This category excludes aircraft owned and leased by the reporting agency. For FY 2010 reporting, owned and leased aircraft are optionally reported under scope 1.

C.1.1 Minimum Required Methodology (User Calculated with GSA Travel MIS Tool)[39]

Data Sources

Air travel emissions can be calculated today for all government agencies and independent commissions in an accurate and scientifically accepted method by GSA's Travel Management Information Service (GSA Travel MIS). This approach requires all agencies to use the GSA Travel MIS system to calculate air travel emissions. Table C-2 shows that the only required data for the Travel MIS tool is the Passenger Name Record (PNR). The PNR is the travel record

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[39] This methodology is based on the TRX Airline Carbon Emissions Calculator, utilized by GSA Travel MIS system.

created for each air travel trip. It provides the complete details of a passenger's booking, including itinerary details such as airline, flight number, class of service, miles traveled.

Table C-2. Air-Travel Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Passenger Name Record (PNR)	• Obtained from the agency's E-Gov Travel Service (ETS) or from their Travel Agency, also called a Travel Management Center (TMC) or Commercial Travel Office (CTO).	N/A

Most agencies and commissions currently have their data available in GSA Travel MIS and can immediately access GHG emission data for their entity for reporting and for planning purposes. Agencies that do not have their data in GSA Travel MIS, can have it available within 2 weeks if they use any of the TMCs or ETSs for which the GSA Travel MIS already has data feeds established. Federal agencies that require a new data feed because their TMC or ETS does not yet have a data feed established with GSA will have a four to six week interval that is needed to establish and test the data feed before they can have access to GHG emission data.

Security

Access to each federal agency's data is restricted to that agency. Agencies cannot see each other's data. GSA only uses summary data for strategic sourcing purposes, such as to support the City Pair Program negotiations.

A security certification and accreditation (C&A) was successfully completed for the GSA Travel MIS by GSA's Designated Approving Authority (DAA). The C&A was completed with the same stringent government requirements adhered to by each of GSA's outsourced ETS vendors.

Reporting Steps

Agencies are required to report air travel emissions for FY 2008 and FY 2010, and must use the PNR as the data source and the GSA Travel MIS to conduct the GHG emissions calculation. The GSA Travel MIS standardizes the calculation and the reporting of the data, while also providing a tool for planning reductions in emissions.

This is achieved through the following steps.

1. Determine if your PNR data is in GSA Travel MIS

2. Obtain a user name and password for the GSA Travel MIS from GSA

3. Access GSA Travel MIS

4. Generate reports of GHG emissions

Step 1: Determine if your PNR data is in GSA Travel MIS

Contact GSA to determine if your PNR data is being submitted. Travel.programs@gsa.gov or telephone 888-472-5585.

If it is not submitted:

> Inform your current travel vendors for which you have a contracted relationship that they are to coordinate with GSA for the transfer of the data to GSA Travel MIS. Some travel vendors, may require the request originate from the contracting officer or contracting officer's technical representative. For other travel vendors, an email providing direction will be sufficient. The communication to your travel vendor can be done using the following:

>> [travel vendor name] is to provide the [federal agency's name] travel data (see attached for a standard list of data elements) to GSA's third party data aggregator beginning with travel commencing on 10/1/2007 through the present. [travel vendor name] shall continue to provide the data on a monthly basis in accordance with its contractual obligations (as specified in the applicable ETS and/or TSS contracts as either an accommodated TMC or an ETS provider). GSA's data aggregator provides a software program which will export for the data automatically each month without requiring any staff resources or [travel vendor name] provide the data using secure FTP.

>> Note: the standard list of data elements can be provided by GSA.

Step 2: Obtain a user name and password for the GSA Travel MIS from GSA

The user name and password will allow access to the GSA Travel MIS.

Step 3: Access GSA Travel MIS

Using your Web browser, access the following url: https://gsa.traveltrax.com and enter your login information.

**Figure C-1: Login Page for GSA Travel MIS**

Step 4: Generate reports of GHG emissions

After successfully logging in to the GSA Travel MIS, select the Regulatory tab. There are two GHG reports under that tab:

1. CO_2 Travel Summary Level 1

2. CO_2 Travel Summary Level 2

The Level 1 report provides the emissions for the overall agency. Level 2 provides the same report, but breaks down emissions to the second level of the agency's organizational hierarchy. For example, a DoD level 1 report would list total DoD-wide emissions, and the level 2 report would list emissions by the associated services.[40]

Figure C-2: GSA Travel MIS Regulatory Tab
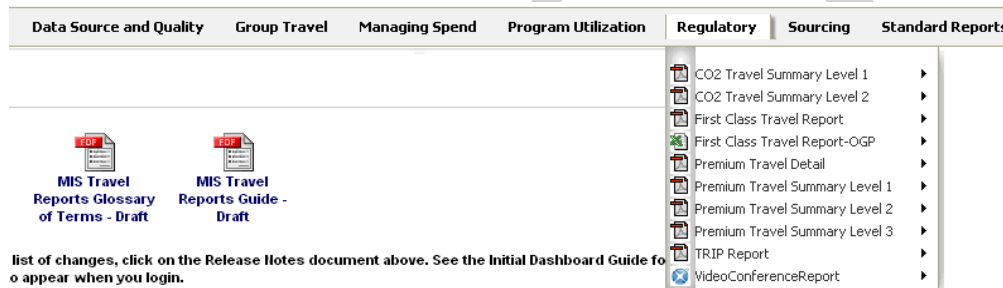
To run the report, move the cursor to the left and highlight *Run Report*.

Figure C-3: Running the Report
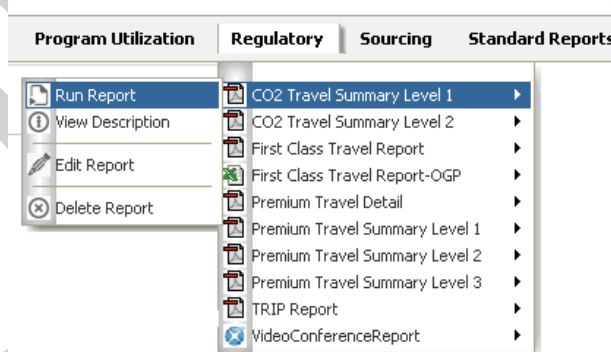
Enter the dates of which you wish to report. The following example compares the base FY 2008 to the first reporting year of FY 2010. After entering the dates, click on *Run* in the lower right corner of the screen, and the report will be generated in pdf format.

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[40] This Level 1/Level 2 breakdown holds for all agencies except the Department of Homeland Security (DHS). For more information on DHS specifics, contact Travel.programs@gsa.gov or telephone 888-472-5585.

Figure C-4: Entering Dates

The following is an example of the Level 1 report. Level 2 simply breaks down the data to the second hierarchical level of the agency.

Figure C-5: Page 1 of the Emissions Report
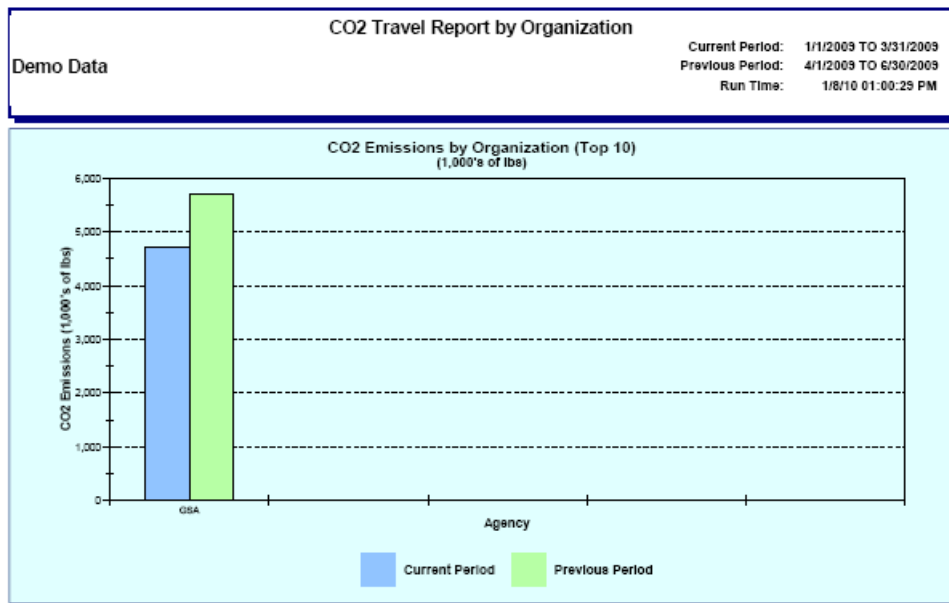
Figure C-6: Page 2 of the Emissions Report
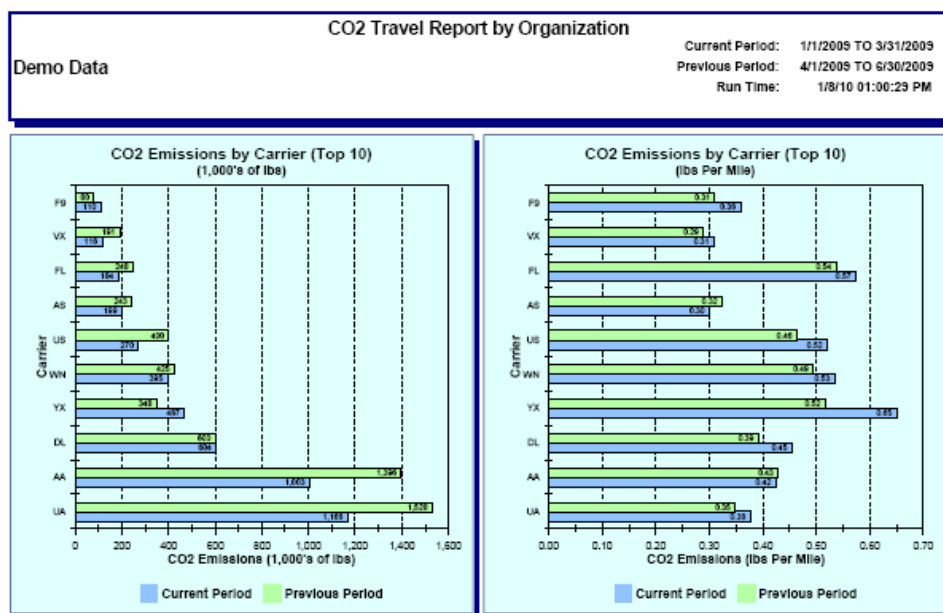
Figure C-7: Page 3 of the Emissions Report

Save the pdf to your hard disk. This report is submitted to DOE to report your FY 2010 emissions in comparison with the base year of FY 2008.[41]

Calculation Methodology

GSA's travel tool follows a detailed methodology to calculate the emissions associated with air travel. Once agencies submit their PNRs, each step in the methodology is done automatically in the tool. This methodology is outlined below:

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[41] The GSA Travel MIS has an interactive dashboard that is to be used for monitoring your GHG emissions and for planning reductions. The dashboard is also under the *Regulatory* tab. This dashboard displays the top 20 city pairs used by your agency during the reporting period. The levers on the right, allow you to adjust the trips taken to these highly traveled city pairs. This provides the ability to conduct your planning for reducing GHG emissions.

Step 1: Calculate the distance traveled for each employee trip

To accurately estimate GHG emissions associated with air travel, the agency's travel service must have data on the originating city and destination city, as well as any connecting cities if the flight is not a non-stop flight.

Step 2: Determine the fuel burn rate for the aircraft

The amount of GHG emissions is directly related to the amount of fuel burned by aircraft. Different aircraft can burn very different amounts of fuel, so it is important to have detailed information on fuel burn rates. The fuel burn rate per passenger is calculated as fuel burned divided by the number of seats. However, the number of seats must be a weighted average or specific to the actual seat size (varying among the cabin classes) in the plane. Additionally, the occupancy rate of the seats in each cabin class must be included.

An accurate fuel burn rate is obtained from the 2006 version of the EMEP/CORINAIR Emission Inventory Guidebook (EIG). This dataset provides fuel consumption data for different aircraft by a range of total journey lengths for each of the different fuel-consumption stages: Taxi out, Take off, Climb-out, Climb/Cruise/Descent, Approach landing, and Taxi in.

Step 3: Calculate CO_2 emissions for the flight

To convert from fuel burned to CO_2 emitted, a factor of 3.15 is used (EIG guidance document, p23). A standard conversion of 2.20 lbs/kg is used to convert from kg to pounds.

Step 4: Determine the cargo and passenger allocation

Cargo consists of passenger baggage, freight, and mail. Cargo and passenger data has been gathered for U.S. carriers from the U.S. Department of Transportation, Bureau of Transportation Statistics (BTS).

The data consists of the weight of the passenger baggage, freight, mail, and passengers. The freight and mail are added together as "cargo." The weight of the passengers and their luggage is derived by taking the number of passengers and multiplying by 100 kg, an industry standard assumption. The data is provided by carrier, by stage (Domestic or International), and by aircraft type for each carrier.

For each carrier, stage, and equipment type, the CO_2 emissions are allocated between cargo and passengers by the percentage of cargo weight to actual payload and the percentage of passenger weight to actual payload. These two values add up to 100 percent.

Step 5: Determine the cabin allocations

CO_2 emissions are allocated among cabin classes to obtain a more accurate amount of the space taken by a passenger's seat. The CO_2 pounds divided by the number of seats on the plane provides the pounds CO_2 per seat, but the seats must be distributed based on real estate since there is a large difference between a premium class and coach seat.

The number of seats for a flight is taken from the Schedules database, while the distribution of seats among the various cabins is taken from the Fleet database. Both databases are available from OAG Back Aviation Solutions. Data from www.SeatGuru.com is used to determine the seat pitch and width of equipment from various carriers which is used to more accurately determine the real estate for each seat.

For each of these, seat pitch and width values are obtained for the cabins (Economy Class, Premium Economy Class, Business Class, and First Class). Additionally, a percentage for each cabin class is obtained (the percentage is the seats in the cabin class/total seats) from the Fleet database. This allows the calculation of the average number of seats for each of the four cabin classes. This value is used with the seat ratio which is calculated as follows.

Step 6: Adjust for passenger load

Typically, airline flights are not 100 percent full. To more accurately calculate CO_2 emissions, is to adjust them to distribute the emissions among the average number of passengers for that carrier. Passenger load factor data is gathered from data supplied by ICAO (The International Civil Aviation Organization), an agency of the United Nations. ICAO is an excellent source of passenger load factor information for both U.S.-carriers and non-U.S. carriers. Data from Calendar Year 2006 is used, to avoid seasonality issues. These values are updated annually. If a carrier is not in the list, then the average load factor of 75.93 percent is used for U.S. carriers, and 67.35 percent for non-U.S. carriers.

C.2 Transmission and Distribution Losses

Description

This category includes the emissions associated with the purchased electricity, steam, heating, and cooling that is consumed in a T&D system.

C.2.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)[42]

Data Sources

Agencies do not need to collect new data to calculate T&D losses. The minimum required calculation methodology uses existing FEMP energy reporting systems and national emission factors to calculate losses.

Table C-5: T&D Losses Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Total national electricity purchase	● Energy Records	N/A
Total steam, hot water, and chilled water purchase	● Energy Records	N/A

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[42] This methodology is based on: Rothschild and Diem (EPA), Guidance on the Use of eGRID Output Emission Rates, April 2009, p. 2, http://www.epa.gov/ttn/chief/conference/ei18/session5/rothschild.pdf.

Data Element	Preferred Source	Alternate Source
National average T&D loss factor (%)	• Electricity: 6.18 % • Steam and chilled water: 10% [Energy Information Administration (EIA) Voluntary Reporting Rule]	EIA
Emission factors	• Electricity: eGRID national factor (Table D-3) • Steam, chilled water, hot water: average factors (Table D-7 and Table D-8)	N/A

Calculation Steps

Electricity

Electricity T&D losses can be calculated using Equation C-1. These calculations take into consideration that eGRID emission factors do not include T&D losses.

1. Retrieve national electricity consumption from FEMP energy reporting

2. Apply national grid emission factor and national average T&D loss factor

Step 1: Retrieve national electricity consumption from FEMP energy reporting

All agencies are currently required to report national electricity consumption through FEMP energy reporting.

Step 2: Apply national grid emission factor and national average T&D loss factor

Agencies should apply national grid emission factors, provided in Appendix D, and the national average T&D loss factor of 6.18 percent. See Equation C-1.

Equation C-1: Electricity Transmission and Distribution Losses

$$CO_{2electricity}\ [kg] = T\&D\ loss\ [\%] \bullet EF_{CO2}\ [kg/MWh] \bullet E_{delivered}\ [MWh] \div (1 - T\&Dloss)\ [\%]$$

$$N_2O_{electricity}\ [kg] = T\&Dloss\ [\%] \bullet EF_{N2O}\ [kg/GWh] \bullet E_{delivered}\ [GWh] \div (1 - T\&Dloss)\ [\%]$$

$$CH_{4electricity}\ [kg] = T\&Dloss\ [\%] \bullet EF_{CH4}\ [kg/GWh] \bullet E_{delivered}\ [GWh] \div (1 - T\&Dloss)\ [\%]$$

Where:

$CO_{2electricity}$ = CO_2 emissions T&D losses [kg].

$N_2O_{electricity}$ = N_2O emissions T&D losses [kg].

$CH_{4electricity}$ = CH_4 emissions T&D losses [kg].

T&Dloss = Transmission and distribution loss factor [%].

EF_{CO2} = eGRID CO_2 emission factor [kg/MWh].

EF_{N2O} = eGRID N_2O emission factor [kg/GWh].

EF_{CH4} = eGRID CH_4 emission factor [kg/GWh].

$E_{delivered}$ = Electricity purchased and delivered [MWh or GWh].

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Steam, Hot Water, and Chilled Water

Steam, hot water, and chilled water T&D losses can be calculated using Equation C-2. These calculations assume that the purchased steam, chilled water, and hot water values include T&D losses.

1. Retrieve national steam, hot water, and chilled water consumption from FEMP energy reporting

2. Apply national average emission factor and national average T&D loss factor

Step 1: Retrieve national electricity consumption from FEMP energy reporting

All agencies are currently required to report national steam, hot water, and chilled water energy consumption through FEMP energy reporting.

Step 2: Apply national grid emission factor and national average T&D loss factor

Agencies should apply national emission factors, provided in Appendix D, and the national average T&D loss factor of 10 percent.[43] See Equation C-2.

Equation C-2: Steam, Hot Water, and Chilled Water Transmission and Distribution Losses

CO_{2steam} **[kg]** = T&Dloss   • EF_{CO2} • $E_{delivered}$
        [%]   [kg/MMBtu]   [MMBtu]

N_2O_{steam} **[kg]** = T&Dloss   • EF_{N2O} • $E_{delivered}$
        [%]   [kg/MMBtu]   [MMBtu]

CH_{4steam} **[kg]** = T&Dloss   • EF_{CH4} • $E_{delivered}$
        [%]   [kg/MMBtu]   [MMBtu]

Where:

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[43] U.S. DOE, Office of Policy and International Affairs, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (March 2006) p. 154-156.

CO_{2steam} = CO_2 emissions from steam/hot water/chilled water T&D losses [kg]

N_2O_{steam} = N_2O emissions from steam/hot water/chilled water T&D losses [kg]

CH_{4steam} = CH_4 emissions from steam/hot water/chilled water T&D losses [kg]

T&Dloss = Steam/hot water/chilled water transmission and distribution loss factor [%]

EF_{CO2} = Steam/hot water/chilled water CO_2 emission factor [kg/MMBtu]

EF_{N2O} = Steam/hot water/chilled water N_2O emission factor [kg/MMBtu]

EF_{CH4} = Steam/hot water/chilled water CH_4 emission factor [kg/MMBtu]

$E_{delivered}$ = Energy purchased and delivered [MMBtu]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

C.3 Contracted Disposal of Waste Generated in Operations

Description

Appendix A provides guidance on inventorying emissions from contracted solid waste disposal. However, data sources will be different for contracted waste disposal and agency controlled waste disposal.

C.3.1 Contracted Solid Waste Minimum Required Methodology (Calculated by GHG Reporting Portal)[44]

Data Sources

Table C-3: Contracted Solid Waste Disposal Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Presence of LFG collection system at the landfill	Waste disposal contractor	If unknown, U.S. average provided
Mass of solid waste disposed	Reporting to Office of the Federal Environmental Executive (OFEE) under EO 13423, Sec. 2(e)	
GWP	Appendix D	
Landfill open year and close year	Waste disposal contractor	Defaults provided in methodology
Methane concentration rate, k	Waste disposal contractor	Default provided by LandGEM
Potential methane generation capacity, Lo	Waste disposal	Default provided by

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[44] This methodology is derived from the EPA LandGEM model (http://www.epa.gov/ttncatc1/products.html) and the EPA Climate Leaders Landfill Offset Methodology (http://www.epa.gov/stateply/documents/resources/draft_landfill_offset_protocol.pdf).

		contractor	LandGEM
NMOC concentration, ppmv		Waste disposal contractor	Default provided by LandGEM
Methane content of LFG, % by volume		Waste disposal contractor	Default provided by LandGEM
If LFG collection system	Efficiency of LFG collection system	Waste disposal division	Default provided by Climate Leaders
	Oxidation factor	Waste disposal division	Default provided by Climate Leaders

Calculation Steps

See Appendix A for the minimum required contracted solid waste calculations.

C.3.2 Contracted Wastewater Treatment Minimum Required Methodology (Calculated by GHG Reporting Portal)[45]

Data Sources

Table C-4: Contracted Wastewater Treatment Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Type of WWTP	● Wastewater treatment contractor	Default provided
Population served	● Agency Records	N/A
GWP	● Table D-4	N/A

Calculation Steps

See Appendix A for the minimum required contracted wastewater calculations.

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[45] This methodology is derived from The Climate Registry's Local Government Operations Protocol (http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/).

C.3.3 Contracted Wastewater Treatment Detailed Methodology (User Calculated)[46]

Data Sources

Table C-5: Contracted Wastewater Treatment Detailed Data Sources

Data Element	Preferred Source	Alternate Source
Detailed methodology: Facility level calculations		
Wastewater treatment processes used	• Wastewater treatment contractor	Default provided
Digester gas (ft^3/day)	• Wastewater treatment contractor	N/A
Fraction of CH_4 in biogas	• Wastewater treatment contractor	N/A
BOD_5 load (kg BOD_5/day)	• Wastewater treatment contractor	N/A
Fraction of overall BOD_5 removal performance	• Wastewater treatment contractor	N/A
N load	• Wastewater treatment contractor	N/A
Population served	• Agency Records	N/A
GWP	• Table D-4	N/A

Calculation Steps

See Appendix A for detailed wastewater calculations.

C.4 Employee Business Travel: Ground Travel (Rail, Rentals, Buses)

Business ground travel includes transportation to move employees to accomplish business-related activities in ground vehicles owned or operated by third parties. Scope 3 emissions from business travel include those from the combustion of fuels (e.g., the fuel consumed by a vehicle), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (e.g., the emissions associated with vehicle manufacturing).

Business Ground travel can be broken down into three categories:

- Passenger vehicle business travel: personal vehicles and taxi cabs

- Rail business travel: transit rail (e.g., subway, tram), commuter rail, and intercity rail (e.g., Amtrak)

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[46] This methodology is derived from The Climate Registry's Local Government Operations Protocol (http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/).

- Bus business travel: diesel fired buses and, to a lesser extent, other fuels such as compressed natural gas (CNG)

Reporting emissions from business ground travel is optional for FY 2010 reporting, but will be required for FY 2011 reporting.

C.4.1 Minimum Required Methodology (Calculated by GHG Reporting Portal)[47]

Data Sources

The minimal required calculation methodology is derived from average travel statistics provided by GSA. The current method is a placeholder for a more robust and accurate method that will be developed in concurrence with GSA.

Table C-6: Ground-Travel Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Number of rentals	• Agency's Travel Agent	N/A
GWP	• Table D-4	N/A

Calculation Steps

Agencies shall use the following steps to calculate emissions:

1. Determine number of agency-wide rentals

2. Calculate miles traveled using a given conversion factor

3. Determine total annual GHG emissions

Step 1: Determine number of agency-wide rentals

Agencies should work with their travel agent to determine how many times agency employees rented vehicles for the fiscal year. This calculation only requires the number of rentals, not the distance traveled per rental or number of days the vehicle was rented.

Step 2: Calculate miles traveled using a given conversion factor

Agencies should multiply the number of rentals by an average factor of 419 miles traveled per rental.[48]

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[47] This methodology is based on correspondence with the GSA Office of Travel and Transportation.

[48] This factor is provided by the GSA Office of Travel and Transportation, based on correspondence with rental agencies. The factor is a national average of all government rentals with three rental companies. These agencies comprise ~40 percent of total federal rentals.

Step 3: Determine total annual GHG emissions in CO_2, N_2O, CH_4, and metric tons of CO_2e using emission factors

Agencies should use equation C-4 and the distance-traveled emission factors in Appendix D Table D-6 and Table D-7 to calculate CO_2, N_2O, and CH_4 emissions for each mode of travel. Agencies should multiply each gas by the appropriate GWP (Table D-4) to find emissions in CO_2e.

C.4.2 Detailed Methodology (User Calculated)[49]

Data Sources

The detailed methodology uses distance-traveled activity data to calculate emissions from ground-travel business travel.

If agencies are unable to obtain adequate distance-traveled data to perform the preferred calculation methodology, agencies may extrapolate total ground-travel emissions from a representative sample of distance-based data.

Table C-7: Ground-Travel Detailed Required Data Sources

Data Element	Preferred Source	Alternate Source
Distance traveled (miles) by mode of ground transport (car, bus, train)	• Rental Vehicles: Agency's Travel Agent • Personal Vehicles: Travel reimbursement forms	• Travel reimbursement forms
Emission Factor	• Table D-7 and Table D-8	N/A
GWP	• Table D-4	N/A

Calculation Steps

The detailed calculation methodology is derived from the EPA Climate Leaders, *Optional Emissions from Commuting, Business Travel and Product Transport,* guidance.

1. Determine distance-traveled for each mode of transportation

2. Calculate emissions for each transportation mode

3. Determine the total annual GHG emissions

Step 1: Determine distance-traveled for each mode of transportation

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[49] This methodology is derived from the Climate Leaders Optional Emissions from Commuting, Business Travel, and Product Transport methodology
(http://www.epa.gov/stateply/documents/resources/commute_travel_product.pdf).

Agencies should gather distance-traveled data on all business ground travel. The distance-traveled data for each mode of transportation can typically be found in travel agent records, or travel reimbursement forms.

If agencies are unable to obtain complete ground travel data, agencies may extrapolate from a representative sample of employees to represent the total business travel of all employees. If agencies choose to extrapolate data, they must report their extrapolation methodology.

Step 2: Calculate emissions for each transportation mode

Agencies should use Equation C-4 and the distance-traveled emission factors in Appendix D Table D-6 and Table D-7 to calculate CO_2, N_2O, and CH_4 emissions for each mode of travel.

Equation C-4: Emissions by Transportation Mode

$$CO_{2mode} \text{ [kg]} = D_{mode} \bullet EF_{CO2}$$
$$\text{[miles]} \quad \text{[kg / mi]}$$

$$N_2O_{mode} \text{ [kg]} = D_{mode} \bullet EF_{N2O}$$
$$\text{[miles]} \quad \text{[kg / mi]}$$

$$CH_{4mode} \text{ [kg]} = D_{mode} \bullet EF_{CH4}$$
$$\text{[miles]} \quad \text{[kg / mi]}$$

Where:

CO_{2mode} = CO_2 emissions for a given transportation mode [kg]

N_2O_{mode} = N_2O emissions for a given transportation mode [kg]

CH_{4mode} = CH_4 emissions for a given transportation mode [kg]

D_{mode} = Total distance traveled for a given transportation mode [miles]

EF_{CO2} = CO_2 emission factor for a given transportation mode [kg/mile]

EF_{N2O} = N_2O emission factor for a given transportation mode [kg/mile]

EF_{CH4} = CH_4 emission factor for a given transportation mode [kg/mile]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 3: Determine the total annual GHG emissions

To determine the total CO_2, N_2O, CH_4 emissions, sum the emissions of each gas for all modes. To determine CO_2 equivalent emissions, multiply the total emissions of each gas by the appropriate GWP and sum the totals. See Table D-4 for GWPs.

Equation C-5: Total Emissions Calculations

$$CO_2 \text{ [kg]} = \Sigma CO_{2mode} \text{ [kg]}$$

$$N_2O \text{ [kg]} = \Sigma N_2O_{mode} \text{ [kg]}$$

CH$_4$ [kg] = ΣCH$_{4mode}$ [kg]

CO$_2$e [metric tons] = (CO$_2$ $\bullet$ GWP$_{CO2}$ + N$_2$O $\bullet$ GWP$_{N2O}$ + CH$_4$ $\bullet$ GWP$_{CH4}$) ÷1,000

Where:

CO$_2$ = Total CO$_2$ emissions [kg]

N$_2$O = Total N$_2$O emissions [kg]

CH$_4$ = Total CH$_4$ emissions [kg]

CO$_2$e = Total CO$_2$e emissions [metric tons]

GWP$_{CO2}$ = Global Warming Potential of CO$_2$ [unitless]

GWP$_{N2O}$ = Global Warming Potential of N$_2$O [unitless]

GWP$_{CH4}$ = Global Warming Potential of CH$_4$ [unitless]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

C.5 Employee Commuter Travel

Description

Employee commuting includes the travel of employees between their homes and primary worksites or between their homes and alternate worksites.

Reporting emissions from business ground travel is optional for FY 2010 reporting, but will be required for FY 2011 reporting.

C.5.1 Detailed Methodology (User Calculated)[50]

Data Sources

Agencies should survey their employees annually to obtain information on average commuting habits. At a minimum, agencies should seek information on:

- Frequency of commute

- Average one-way distance traveled by employee per day

- Mode(s) of transport used by employees (personal vehicle, train, bus, etc)

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[50] This methodology is derived from the Climate Leaders Optional Emissions from Commuting, Business Travel, and Product Transport methodology (http://www.epa.gov/stateply/documents/resources/commute_travel_product.pdf).

Agencies should collect employee commuting data from as many employees as possible. However, some use of extrapolation will be necessary. Agencies may extrapolate from representative sample of employees to represent the total commuting patterns of all employees.

If agencies are unable to survey their employees, they should look to onsite data sources such as parking permits or payroll records to gather information on distance traveled, mode of transport, and frequency of commute. If no on-site data is available, agencies should use regional or national databases such as the U.S. Census Bureau or Center for Neighborhood Technology.

Table C-6: Commuter Travel Detailed Data Sources

Data Element	Preferred Source	Alternate Source
Mode	• Commuter survey	• Public transit records • Regional/National transportation surveys
Number of trips (by mode)	• Commuter survey	• Regional/National transportation surveys (U.S. Census Bureau, Center for Neighborhood Technology)
Distance of trip (by mode)	• Commuter survey	• Commuter address (payroll records, personnel records, parking permits) • National / state / local transportation surveys
Emission factors	Table D-8 and Table D-9	N/A
GWP	Table D-4	N/A

Calculation Steps

1. Determine number of trips, distance of trips, and mode of travel activity data

2. Calculate emissions for each transportation mode

3. Determine the total annual GHG emissions in CO_2, N_2O, CH_4, and metric tons of CO_2e

Step 1: Determine frequency, distance, and mode travel activity data

The activity data for commuters can be established using a commuter survey. If the agency is unable to survey its workforce, agencies should gather activity data through on-site records or regional/national data sources. It should be noted that in order to account for emission saving strategies that focus on modifying employee commute behavior (e.g., encouraging use of carpooling or public transit), agencies must use commuter survey data specific to the agency population.

Step 2: Calculate emissions of each mode

Agencies should use the following equation to calculate CO_2, CH_4, and N_2O emissions for each mode of travel. Emissions factors can be found in Table D-6 and Table D-7.

Equation C-3: Emissions by Transportation Mode

CO_{2mode} [kg] $= T_{mode}$	$\bullet \quad D_{mode}$	$\bullet \quad EF_{mode,CO2}$
[trips / year]	[miles / trip]	[kg / mile]
N_2O_{mode} [kg] $= T_{mode}$	$\bullet \quad D_{mode}$	$\bullet \quad EF_{mode,N2O}$
[miles]	[kg / mi]	[kg / mile]
CH_{4mode} [kg] $= T_{mode}$	$\bullet \quad D_{mode}$	$\bullet \quad EF_{mode,CH4}$
[miles]	[kg / mi]	[kg / mile]

Where:

CO_{2mode} = CO_2 emissions for a given transportation mode [kg]

N_2O_{mode} = N_2O emissions for a given transportation mode [kg]

CH_{4mode} = CH_4 emissions for a given transportation mode [kg]

T_{mode} = Number of trips made per year for a given transportation mode [trips]

D_{mode} = Total distance traveled for a given transportation mode [miles / trip]

EF_{CO2} = CO_2 emission factor for a given transportation mode [kg/mile]

EF_{N2O} = N_2O emission factor for a given transportation mode [kg/mile]

EF_{CH4} = CH_4 emission factor for a given transportation mode [kg/mile]

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport

Step 3: Determine the total annual GHG emissions in CO_2, N_2O, CH_4, and metric tons of CO_2e

To determine the total CO_2, N_2O, CH_4 emissions, sum the emissions from all modes by emission type. To determine CO_2 equivalent emissions, multiply the total emissions of each gas by the appropriate GWP and sum the MT CO_2e emissions. See Table D-4 for GWPs. See Equation C-3 for relevant equations.

C.6 Contracted Wastewater Treatment

Description

Appendix A provides guidance on inventorying emissions from contracted wastewater treatment. However, data sources will be different for contracted wastewater treatment and agency controlled wastewater treatment.

C.6.1 Contracted Wastewater Treatment Minimum Required Methodology (Calculated by GHG Reporting Portal)[51]

Data Sources

Table C-8: Contracted Wastewater Treatment Minimum Required Data Sources

Data Element	Preferred Source	Alternate Source
Type of WWTP	• Wastewater treatment contractor	Default provided
Population served	• Agency Records	N/A
GWP	• Table D-4	N/A

Calculation Steps

See Appendix A for the minimum required contracted wastewater calculations.

C.6.2 Contracted Wastewater Treatment Detailed Methodology (User Calculated)[52]

Data Sources

Table C-9: Contracted Wastewater Treatment Detailed Data Sources

Data Element	Preferred Source	Alternate Source
Detailed methodology: Facility level calculations		
Wastewater treatment processes used	• Wastewater treatment contractor	Default provided
Digester gas (ft^3/day)	• Wastewater treatment contractor	N/A
Fraction of CH_4 in biogas	• Wastewater treatment contractor	N/A
BOD_5 load (kg BOD_5/day)	• Wastewater treatment contractor	N/A
Fraction of overall BOD_5 removal performance	• Wastewater treatment contractor	N/A
N load	• Wastewater treatment contractor	N/A
Population served	• Agency Records	N/A

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[51] This methodology is derived from The Climate Registry's Local Government Operations Protocol (http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/).

[52] This methodology is derived from The Climate Registry's Local Government Operations Protocol (http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/).

Data Element	Preferred Source	Alternate Source
GWP	• Table D-4	N/A

Calculation Steps

See Appendix A for detailed wastewater calculations.

C.7 Leased Assets from GSA and the Private Sector not included in Scopes 1 and 2

Agencies should not inventory emissions from leased assets from GSA and the private sector not included in scopes 1 and 2 at this time. Methodologies for calculating emissions from tenants will be developed prior to FY 2011 reporting.

Appendix D – Emission and Conversion Factors

The emission factors and conversion factors found in Appendix D are summarized in the following table:

Factor Type	Data Source Reference	Reference Section	Appendix D Table #	Applicable Scope(s)
Global Warming Potentials	EPA Mandatory Greenhouse Gas Reporting Rule, *Federal Register, Friday, October 30, 2009* http://www.epa.gov/climatechange/emissions/ghgrulemaking.html	Table A-1 to Subpart A of Part 98	D-4	All
Conversion Factors		Table A-2 to Subpart A of Part 98	D-5	All
CO_2 Emission Factors and High Heat Values for Various Types of Fuel		Table C-1 to Subpart C of Part 98	D-1	Scope 1
CH_4 and N_2O Emission Factors for Various Types of Fuel		Table C-2 to Subpart C of Part 98	D-2	Scope 1, Other reporting
eGRID Subregion and National Emission Rates (all generation and baseload-only	Source: eGrid2007 Version 1.1 Year 2005 Summary Tables, p. 6,[53] http://www.epa.gov/RDEE/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf	Source: eGrid2007 Version 1.1 Year 2005 Summary Tables, p. 6,	D-3	Scope 2 & 3
Steam/Hot Water Emission Factor	DOE 1605(b): http://www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf	Appendix N	D-9	Scope 2 & 3
Chilled Water Emission Factors	TCR Local Government Operations Protocol, http://www.icleiusa.org/action-center/tools/lgo-protocol-1	N/A	D-10	Scope 2 & 3
Grid Loss Factors	EPA eGrid2007 Version 1.1 State Import-Export File (Year 2005 Data) http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007_Version1-1.zip	N/A	D-6	Scope 2 & 3

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[53] The FEMP Reporting Capability will include the latest eGRID emission factors.

Personal Vehicle Emission Factors	EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport	EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport	D-7	Scope 1 & 3
Public Transit Emission Factors		EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport	D-8	Scope 1 & 3

Key Emission Factors

For scope 1 and 2 emissions, agencies should use emission factors from the EPA's Mandatory Greenhouse Gas Reporting Rule (MRR). These factors are listed in Table D-1 and Table D-2 below.

For purchased electricity (scope 2), agencies should use emission factors in derived from the EPA eGRID database. This database divides the grid into 26 subregions with unique emission factors based on the regional electricity generation mix. **Error! Reference source not found.** hows the eGRID subregions. Agencies can map a facility's zip code to the corresponding eGRID subregion using the EPA Power Profiler website.[54]

For scope 3 emissions, or emissions not covered by the MRR or eGRID database, agencies should use emission factors from the EPA AP 42, fifth edition.[55] Agencies should refer to the EPA AP 42 website to ensure their emission factors are current.

Table D-1: Default CO2 Emission Factors and High Heat Values for Various Types of Fuel

Fuel Type	Default high heat value	Default CO_2 emission factor
Coal and coke	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Anthracite	25.09	103.54
Bituminous	24.93	93.40
Subbituminous	17.25	97.02
Lignite	14.21	96.36
Coke	24.80	102.04
Mixed (Commercial sector)	21.39	95.26
Mixed (industrial coking)	26.28	93.65
Mixed (industrial sector)	22.35	93.91

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[54] EPA Power Profiler http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html.
[55] EPA AP 42 http://www.epa.gov/ttn/chief/ap42/index.html.

Mixed (Electric Power sector)	19.73	94.38
Natural Gas	**MMBtu/scf**	**Kg CO_2/MMBtu**
Pipeline (Weighted U.S. Average)	1.028×10^{-3}	53.02
Petroleum Products	**MMBtu/gallon**	**Kg CO_2/MMBtu**
Distillate Fuel Oil No. 1	0.139	73.25
Distillate Fuel Oil No. 2	0.138	73.96
Distillate Fuel Oil No. 4	0.146	75.04
Distillate Fuel Oil No. 5	0.140	72.93
Distillate Fuel Oil No. 6	0.150	75.10
Still gas	0.143	66.72
Kerosene	0.135	75.20
Liquefied petroleum gases (LPG)	0.092	62.98
Propane	0.091	61.46
Propylene	0.091	65.95
Ethane	0.096	62.64
Ethylene	0.100	67.43
Isobutene	0.097	64.91
Isobutylene	0.103	67.74
Butane	0.101	65.15
Butylene	0.103	67.73
Naphtha (<401 degrees F)	0.125	68.02
Natural gasoline	0.110	66.83
Other oil (>401 degrees F)	0.139	76.22
Pentanes plus	0.110	70.02
Petrochemical feedstocks	0.129	70.97
Petroleum coke	0.143	102.41
Special naphtha	0.125	72.34
Unfinished oils	0.139	74.49
Heavy gas oils	0.148	74.92
Lubricants	0.144	74.27
Motor gasoline	0.125	70.22
Aviation gasoline	0.120	69.25
Kerosene-type jet fuel	0.135	72.22
Asphalt and road oil	0.158	75.36
Crude oil	0.138	74.49
Fossil fuel-derived fuels (solid)	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Municipal solid waste	9.95	90.7

Tires	26.87	85.97
Fossil fuel-derived fuels (gaseous)	**MMBtu/scf**	**Kg CO_2/MMBtu**
Blast furnace gas	0.092×10^{-3}	274.32
Coke oven gas	0.599×10^{-3}	46.85
Biomass fuels – solid	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Wood and wood residuals	15.38	93.80
Agricultural byproducts	8.25	118.17
Peat	8.00	111.84
Solid byproducts	25.83	105.51
Biomass fuels – gaseous	**MMBtu/scf**	**Kg CO_2/MMBtu**
Biogas (captured methane)	0.841×10^{-3}	52.07
Biomass fuels – liquid	**MMBtu/gallon**	**Kg CO_2/MMBtu**
Ethanol (100%)	0.084	68.44
Biodiesel (100%)	0.128	73.84
Rendered animal fat	0.125	71.06
Vegetable oil	0.120	81.55

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table C-1 to Subpart C of Part 98.

Table D-2: Default CH4 and N2O Emission Factors for Various Types of Fuel

Fuel type	Default CH_4 emission factor (kg CH_4/MMBtu)	Default N_2O emission factor (kg N_2O/MMBtu)
Coal and Coke (All fuel types in Table D-1)	1.1×10^{-2}	1.6×10^{-3}
Natural gas	1.0×10^{-3}	1.0×10^{-4}
Petroleum (All fuel types in Table D-1)	3.0×10^{-3}	6.0×10^{-4}
Municipal solid waste	3.2×10^{-2}	4.2×10^{-3}
Tires	3.2×10^{-2}	4.2×10^{-3}
Blast furnace gas	2.2×10^{-5}	1.0×10^{-4}
Coke oven gas	4.8×10^{-4}	1.0×10^{-4}
Biomass fuels – solid (All fuel types in Table D-1)	3.2×10^{-2}	4.2×10^{-3}
Biogas	3.2×10^{-3}	6.3×10^{-4}
Biomass fuels – liquid (All fuel types in Table D-1)	1.1×10^{-3}	1.1×10^{-4}

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table C-2 to Subpart C of Part 98.

Table D-3: Grid2007 Year 2005 Subregion Emission Rates

eGRID subregion acronym	eGRID subregion name	Output emission rates			Fossil fuel output emission rates	Non-baseload output emission rates		
		CO_2 (kg/MWh)	CH_4 (kg/GWh)	N_2O (kg/GWh)	CO_2 (kg/MWh)	CO_2 (kg/MWh)	CH_4 (kg/GWh)	N_2O (kg/GWh)
AKGD	ASCC Alaska Grid	558.99	11.61	2.95	633.20	668.33	16.52	3.74
AKMS	ASCC Miscellaneous	226.28	9.41	1.85	642.85	660.93	27.43	5.38
AZNM	WECC Southwest	594.68	7.92	8.14	766.43	544.96	9.43	3.86
CAMX	WECC California	328.45	13.72	3.67	568.53	491.25	17.80	2.52
ERCT	ERCOT All	600.71	8.46	6.85	695.77	507.50	9.14	2.58
FRCC	FRCC All	598.09	20.83	7.68	635.78	614.03	21.84	5.87
HIMS	HICC Miscellaneous	687.15	142.74	21.26	769.92	759.38	153.51	23.32
HIOA	HICC Oahu	821.90	49.65	10.71	816.60	841.45	54.48	9.43
MORE	MRO East	832.21	12.51	13.77	1005.37	829.45	13.07	11.43
MROW	MRO West	826.37	12.70	13.93	1049.13	979.21	20.67	15.98
NEWE	NPCC New England	420.79	39.23	7.72	613.92	596.26	35.14	7.27
NWPP	WECC Northwest	409.25	8.68	6.76	894.92	604.93	22.35	8.50
NYCW	NPCC NYC/Westchester	369.88	16.34	2.48	642.55	691.75	25.76	4.12
NYLI	NPCC Long Island	697.08	52.35	8.21	654.56	684.85	27.36	4.89
NYUP	NPCC Upstate NY	326.95	11.26	5.08	705.03	686.79	20.55	8.35
RFCE	RFC East	516.67	13.73	8.49	758.94	812.15	18.87	11.05
RFCM	RFC Michigan	709.09	15.39	12.32	768.78	754.39	13.34	11.90
RFCW	RFC West	697.54	8.27	11.66	897.18	903.94	11.11	14.39
RMPA	WECC Rockies	854.15	10.38	13.04	936.38	733.78	10.17	9.14
SPNO	SPP North	889.46	10.80	14.56	1035.75	984.17	14.14	14.51
SPSO	SPP South	752.12	11.33	10.26	804.66	625.52	11.07	5.46
SRMV	SERC Mississippi Valley	462.54	11.03	5.31	644.77	570.21	13.38	4.45
SRMW	SERC Midwest	830.30	9.59	13.83	954.14	953.07	11.64	14.93
SRSO	SERC South	675.64	11.92	11.55	885.17	769.84	15.97	11.98
SRTV	SERC Tennessee Valley	685.12	9.09	11.63	953.17	906.44	12.81	14.90
SRVC	SERC Virginia/Carolina	514.77	10.78	8.98	861.68	807.97	18.18	12.46
U.S.		**602.98**	**12.37**	**9.34**	**815.38**	**718.16**	**16.22**	**9.06**

Source: eGrid2007 Version 1.1 Year 2005 Summary Tables, p. 6,
http://www.epa.gov/RDEE/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf.

Global Warming Potentials

Table D-4: Global Warming Potentials

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
Carbon dioxide	124–38–9	CO_2	1
Methane	74–82–8	CH_4	21
Nitrous oxide	10024–97–2	N_2O	310
HFC–23	75–46–7	CHF_3	11,700
HFC–32	75–10–5	CH_2F_2	650
HFC–41	593–53–3	CH_3F	150
HFC–125	354–33–6	C_2HF_5	2,800
HFC–134	359–35–3	$C_2H_2F_4$	1,000
HFC–134a	811–97–2	CH_2FCF_3	1,300
HFC–143	430–66–0	$C_2H_3F_3$	300
HFC–143a	420–46–2	$C_2H_3F_3$	3,800
HFC–152	624–72–6	CH_2FCH_2F	53
HFC–152a	75–37–6	CH_3CHF_2	140
HFC–161	353–36–6	CH_3CH_2F	12
HFC–227ea	431–89–0	C_3HF_7	2,900
HFC–236cb	677–56–5	$CH_2FCF_2CF_3$	1,340
HFC–236ea	431–63–0	CHF_2CHFCF_3	1,370
HFC–236fa	690–39–1	$C_3H_2F_6$	6,300
HFC–245ca	679–86–7	$C_3H_3F_5$	560
HFC–245fa	460–73–1	$CHF_2CH_2CF_3$	1,030
HFC–365mfc	406–58–6	$CH_3CF_2CH_2CF_3$	794
HFC–43–10mee	138495–42–8	$CF_3CFHCFHCF_2CF_3$	1,300
Sulfur hexafluoride	2551–62–4	SF_6	23,900
Trifluoromethyl sulphur pentafluoride	373–80–8	SF_5CF_3	17,700
Nitrogen trifluoride	7783–54–2	NF_3	17,200
PFC–14 (Perfluoromethane)	75–73–0	CF_4	6,500
PFC–116 (Perfluoroethane)	76–16–4	C_2F_6	9,200
PFC–218 (Perfluoropropane)	76–19–7	C_3F_8	7,000
Perfluorocyclopropane	931–91–9	$C\text{-}C_3F_6$	17,340
PFC–3–1–10 (Perfluorobutane)	355–25–9	C_4F_{10}	7,000
Perfluorocyclobutane	115–25–3	$C\text{-}C_4F_8$	8,700
PFC–4–1–12	678–26–2	C_5F_{12}	7,500

(Perfluoropentane)			
PFC–5–1–14 (Perfluorohexane)	355–42–0	C_6F_{14}	7,400
PFC–9–1–18	306–94–5	$C_{10}F_{18}$	7,500
HCFE–235da2 (Isoflurane)	26675–46–7	$CHF_2OCHClCF_3$	350
HFE–43–10pccc (H–Galden 1040x)	E1730133	$CHF_2OCF_2OC_2F_4OCHF_2$	1,870
HFE–125	3822–68–2	CHF_2OCF_3	14,900
HFE–134	1691–17–4	CHF_2OCHF_2	6,320
HFE–143a	421–14–7	CH_3OCF_3	756
HFE–227ea	2356–62–9	$CF_3CHFOCF_3$	1,540
HFE–236ca12 (HG–10)	78522–47–1	$CHF_2OCF_2OCHF_2$	2,800
HFE–236ea2 (Desflurane)	57041–67–5	$CHF_2OCHFCF_3$	989
HFE–236fa	20193–67–3	$CF_3CH_2OCF_3$	487
HFE–245cb2	22410–44–2	$CH_3OCF_2CF_3$	708
HFE–245fa1	84011–15–4	$CHF_2CH_2OCF_3$	286
HFE–245fa2	1885–48–9	$CHF_2OCH_2CF_3$	659
HFE–254cb2	425–88–7	$CH_3OCF_2CHF_2$	359
HFE–263fb2	460–43–5	$CF_3CH_2OCH_3$	11
HFE–329mcc2	67490–36–2	$CF_3CF_2OCF_2CHF_2$	919
HFE–338mcf2	156053–88–2	$CF_3CF_2OCH_2CF_3$	552
HFE–338pcc13 (HG–01)	188690–78–0	$CHF_2OCF_2CF_2OCHF_2$	1,500
HFE–347mcc3	28523–86–6	$CH_3OCF_2CF_2CF_3$	575
HFE–347mcf2	E1730135	$CF_3CF_2OCH_2CHF_2$	374
HFE–347pcf2	406–78–0	$CHF_2CF_2OCH_2CF_3$	580
HFE–356mec3	382–34–3	$CH_3OCF_2CHFCF_3$	101
HFE–356pcc3	160620–20–2	$CH_3OCF_2CF_2CHF_2$	110
HFE–356pcf2	E1730137	$CHF_2CH_2OCF_2CHF_2$	265
HFE–356pcf3	35042–99–0	$CHF_2OCH_2CF_2CHF_2$	502
HFE–365mcf3	378–16–5	$CF_3CF_2CH_2OCH_3$	11
HFE–374pc2	512–51–6	$CH_3CH_2OCF_2CHF_2$	557
HFE–449sl (HFE–7100) Chemical blend	163702–07–6 163702–08–7	$C_4F_9OCH_3$ $(CF_3)_2CFCF_2OCH_3$	297
HFE–569sf2 (HFE–7200) Chemical blend	163702–05–4 163702–06–5	$C_4F_9OC_2H_5$ $(CF_3)_2CFCF_2OC_2H_5$	59
Sevoflurane	28523–86–6	$CH_2FOCH(CF_3)_2$	345
HFE–356mm1	13171–18–1	$(CF_3)_2CHOCH_3$	27
HFE–338mmz1	26103–08–2	$CHF_2OCH(CF_3)_2$	380
(Octafluorotetramethy-lene)hydroxymethyl group	NA	$X-(CF_2)_4CH(OH)-X$	73

HFE–347mmy1	22052–84–2	$CH_3OCF(CF_3)_2$	343
Bis(trifluoromethyl)-methanol	920–66–1	$(CF_3)_2CHOH$	195
2,2,3,3,3-pentafluoropropanol	422–05–9	$CF_3CF_2CH_2OH$	42
PFPMIE	NA	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	10,300

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table A-1 to Subpart A of Part 98.

Conversion Factors

Table D-5: Conversion Factors

To convert from	To	Multiply by
Weight		
Kilograms (kg)	Pounds (lbs)	2.20462
Pounds (lbs)	Kilograms (kg)	0.45359
Pounds (lbs)	Metric tons	4.53592×10^{-4}
Short tons	Pounds (lbs)	2,000
Short tons	Metric tons	0.90718
Metric tons	Short tons	1.10231
Metric tons	Kilograms (kg)	1,000
Million metric tons CO_2e (MMT CO_2e)	Metric tons CO_2e (MT CO_2e)	1,000,000
Metric tons (MT)	Tons	1
Volume		
Cubic meters (m^3)	Cubic feet (ft^3)	35.31467
Cubic feet (ft^3)	Cubic meters (m^3)	0.028317
Gallons (liquid, US)	Liters (l)	3.78541
Liters (l)	Gallons (liquid, US)	0.26417
Barrels of Liquid Fuel (bbl)	Cubic meters (m^3)	0.15891
Cubic meters (m3)	Barrels of Liquid Fuel (bbl)	6.289
Barrels of Liquid Fuel (bbl)	Gallons (liquid, US)	42
Gallons (liquid, US)	Barrels of Liquid Fuel (bbl)	0.023810
Gallons (liquid, US)	Cubic meters (m^3)	0.0037854
Liters (l)	Cubic meters (m^3)	0.001
Distance		
Feet (ft)	Meters (m)	0.3048
Meters (m)	Feet (ft)	3.28084
Miles (mi)	Kilometers (km)	1.60934

Kilometers (km)	Miles (mi)	0.62137
Area		
Square feet (ft2)	Acres	2.29568×10^{-5}
Square meters (m2)	Acres	2.47105×10^{-4}
Square miles (mi2)	Square kilometers (km2)	2.58999
Temperature		
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	$°C = (5/9) \times (°F - 32)$
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	$°F = (9/5) \times °C + 32$
Degrees Celsius (°C)	Kelvin (K)	$K = °C + 273.15$
Kelvin (K)	Degrees Rankine (°R)	1.8
Energy		
Joules	Btu	9.47817×10^{-4}
Btu	MMBtu	1×10^{-6}
Pressure		
Pascals (Pa)	Inches of Mercury (in Hg)	2.95334×10^{-4}
Inches of Mercury (inHg)	Pounds per square inch (psi)	0.49110
Pounds per square inch (psi)	Inches of Mercury (in Hg)	2.03625
Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009 Table A-2 to Subpart A of Part 98.		

Miscellaneous Emission Factors

Table D-6: Personal Vehicle Emission Factors

Vehicle type	CO_2 emissions factor (Kg CO_2 / vehicle-mile)	CH_4 emissions factor (kg CH_4 / vehicle-mile)	N_2O emissions factor (kg N_2O / vehicle-mile)
Passenger Car	0.364	0.031×10^{-3}	0.032×10^{-3}
Light-duty Truck/ Van/ SUV	0.519	0.036×10^{-3}	0.047×10^{-3}
Motorcycle	0.167	0.070×10^{-3}	0.007×10^{-3}

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Table D-7: Public Transit Emission Factors

Vehicle type	CO_2 emissions factor (kg CO_2 / passenger-mile)	CH_4 emissions factor (kg CH_4 / passenger-mile)	N_2O emissions factor (kg N_2O / passenger-mile)
Bus	0.107	0.0006×10^{-3}	0.0005×10^{-3}
Transit Rail	0.163	0.004×10^{-3}	0.002×10^{-3}
Commuter Rail	0.172	0.002×10^{-3}	0.001×10^{-3}
Intercity Rail	0.185	0.002×10^{-3}	0.001×10^{-3}

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Table D-8: Steam/Hot Water Emission Factor

	Emission Factor (CO_2e kg/MMBtu)
Steam/Hot Water*	86.85

Source: DOE 1605(b): http://www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

*This assumes a 10-percent loss during transmission.

Table D-9: Chilled Water Emission Factors

Chiller Type	Emission Factor (kg CO_2e/Ton-hours Cooling)
Absorption Chiller	0.8
Engine-Driven Chiller	1.2
Electric-Driven Chiller	4.2

Source: DOE 1605(b), Technical Guidance